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REGIONAL ANATOMY

VOLUME II

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REGIONAL ANATOMY

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Volume II

THE ABDOMEN AND THORAX

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THE ABDOMEN

The study of the abdomen comprises an examination of the following regions:—

1. The perineum.
    (*a*) In the male.
    (*b*) In the female.
2. The abdominal wall.
3. The abdominal cavity.
4. The pelvis.
    (*a*) In the male.
    (*b*) In the female.

I. THE MALE PERINEUM

Anatomical Definition.—The perineum, as defined in human anatomy, corresponds to the inferior aperture or the outlet of the pelvis. The true pelvis possesses an inlet or pelvic brim, which is formed by the ilio-pectineal lines, and which separates the false pelvis above from the true pelvis below, a cavity, and an inferior aperture, or outlet of the pelvis. This outlet constitutes the *anatomical perineum.*

Shape.—The anatomical perineum is a diamond-shaped space, with the coccyx projecting forwards from the posterior angle of the space. This space in the recent condition is traversed by the rectum and urethra in the male, and in the female by the vagina in addition.

Boundaries.—*In front* are the symphysis pubis and the subpubic ligament. *On either side* from before backwards, the conjoined rami of the pubis and ischium, the ischial tuberosity, and the great sacro-sciatic ligament. *Behind* is the coccyx, projecting forwards into the space.

In the living subject the superficial area of the perineum is very limited. It merely consists of a narrow groove running between the thighs from the symphysis pubis to the coccyx.

Division of the Space.—The perineum is divided by an imaginary line drawn transversely between the two ischial tuberosities. This line passes in front of the anus and divides the perineum into two triangles—

A posterior or rectal triangle.
An anterior or uro-genital triangle.

Each of these triangles is further subdivided quite naturally as follows:—The rectum passes through the posterior triangle in the middle line of the body. After dissection a space or fossa is found to exist on each side of the rectum and between it and the lateral walls of the pelvis. These fossæ are termed the ischio-rectal fossæ. The rectum may therefore be regarded as subdividing the posterior triangle into the two ischio-rectal fossæ.

The anterior triangle is also subdivided quite naturally by the triangular ligament into two pouches—the superficial and the deep perineal pouches.

The divisions and subdivisions of the anatomical perineum may therefore be summarised as follows:—

Perineum.	Uro-genital triangle.	(*a*) Superficial perineal pouch. (*b*) Deep perineal pouch.
	Rectal triangle.	(*a*) Ischio-rectal fossa. (*b*) Ischio-rectal fossa.

I. **The Posterior or Rectal Triangle.**—The rectal triangle is bounded *in front* by the imaginary line drawn between the two ischial tuberosities, *laterally* by the ischial tuberosities themselves and the great sacro-sciatic ligament covered by the gluteus maximus muscle, and *behind* by the coccyx.

The rectum passes through this triangle to its termination at the anus; and on either side of the rectum, between it and the osseous boundaries of the space, there is a mass of fat occupying an interval, termed the *ischio-rectal fossa.*

The Ischio-Rectal Fossa.—The ischio-rectal fossa is that part of the rectal triangle of the perineum which lies between the pelvic wall and the lower end of the rectum.

Shape.—The fossa is irregularly pyramidal in shape, with a base, an apex, and four sides or walls.

The Base.—In the erect or anatomical position of the body the base looks downwards. It is formed by the cutaneous structures between the ischial tuberosities and the anus, and measures about two inches from before backwards, and one inch from side to side.

The Apex.—The apex looks upwards, and is formed by the convergence of the inner and outer walls of the space to what is termed the "white line." This separates the fossa from the cavity of the true pelvis.

The Outer Wall.—The outer wall is almost perpendicular, and extends upwards for nearly two inches. It is bounded by the obturator internus muscle clothed by its fascia, the obturator fascia. Passing forwards in this wall is a tunnel of fascia termed Alcock's canal, and lying in this canal, about one inch above the ischial tuberosity, are the dorsal nerve of the penis, the pudic vessels, and the perineal nerve.

The Inner Wall.—The inner wall is oblique and somewhat convex downwards. It is formed by the levator ani muscle clothed by the thin anal fascia.

The Anterior Wall.—The anterior wall is bounded by the base of the triangular ligament covered by the transverse perineal muscle.

The Posterior Wall.—The posterior wall is bounded by the great sacro-sciatic ligament covered by the gluteus maximus muscle.

In each wall of the ischio-rectal fossa there is one muscle and one other structure.

Contents of the Ischio-Rectal Fossa.—These are as follows:—

Muscles.

- The sphincter ani externus muscle.
- The sphincter ani internus muscle.
- The levator ani muscle.

Vessels.

- The internal pudic vessels.
- The inferior hæmorrhoidal vessels.

Nerves.

- The pudic nerve breaking up into its three main divisions—

The inferior hæmorrhoidal nerve.
The perineal nerve.
The dorsal nerve of the penis.
The perineal branch of the fourth sacral nerve.
The perforating cutaneous branch of the sacral plexus.

Other Structures.

Fat.
The ano-coccygeal body.

In connection with the above-mentioned contents it must be recollected that they are not all, strictly speaking, situated in the fossa, but on account of their intimate relations with the fossa it is convenient to discuss them in this way.

The Sphincter Ani Externus.—The external sphincter of the anus is an orbicular muscle surrounding the lower end of the rectum. It is elliptical in form, and nearly one inch in depth. When the anus is distended, as during the passage of fæces, the muscle looses its elliptical form and becomes almost circular.

Attachments.—In front the muscular fibres are attached to the skin and the central point of the perineum. Passing backwards, the fibres divide to surround the anus, and are attached posteriorly to the tip and back of the coccyx and the overlying integuments.

Nerve Supply.—The fourth sacral nerve and the inferior hæmorrhoidal branch of the pudic nerve.

The Sphincter Ani Internus.—This muscle is merely a specially thickened part of the circular muscular fibres of the rectum. It is a purely involuntary muscle.

The Levator Ani.—This muscle is described with the pelvis. (*See* page 181.)

The Internal Pudic Artery.—This vessel, one of the terminal branches of the anterior division of the internal iliac artery, arises within the pelvic cavity, and is ultimately distributed to the perineum and the external organs of generation.

Leaving the buttock the artery enters the ischio-rectal fossa through the small sacro-sciatic foramen, and runs forwards along the outer wall of that fossa about one inch above the ischial tuberosity.

In this course the artery is contained in a special sheath of the obturator fascia termed Alcock's canal, and is accompanied by two venæ comites and two nerves, the dorsal nerve of the penis lying above it and the perineal branch of the pudic nerve below it.

The artery leaves the ischio-rectal fossa and enters the uro-genital triangle by piercing the base of the triangular ligament. Its subsequent course will be considered with the uro-genital triangle.

The Inferior Hæmorrhoidal Artery.—This vessel, frequently represented by two or more branches, arises from the internal pudic artery as it enters the perineal space, a little below the lesser sacro-sciatic foramen. Running forwards and inwards towards the anus, the vessel supplies the muscles and skin near the anus, and anastomoses with its fellow of the opposite side and with the terminal branches of the superior hæmorrhoidal arteries.

The Pudic Nerve.—This nerve, a branch from the lower part of the sacral plexus, arises within the pelvic cavity, and is ultimately distributed to the perineum and external organs of generation.

The nerve enters the ischio-rectal fossa in the same manner as the artery, but, unlike the artery, it immediately breaks up into its three terminal branches.

This division takes place in the small sacro-sciatic foramen, and is as follows:—

The inferior hæmorrhoidal nerve.
The dorsal nerve of the penis, or of the clitoris.
The perineal nerve.

The Inferior Hæmorrhoidal Nerve.—This nerve passes across the ischio-rectal fossa accompanied by the artery of the same name, from the posterior wall of the fossa, forwards and inwards towards the margin of the anus, where it terminates by dividing into numerous branches which supply the external sphincter ani muscle and the skin over the posterior part of the perineum.

Its most anterior cutaneous branches pass forwards and communicate with the long pudendal branch of the small sciatic nerve and with the superficial perineal nerves.

The inferior hæmorrhoidal nerve is occasionally derived directly from the sacral plexus.

The Dorsal Nerve of the Penis.—This nerve passes through the ischio-rectal fossa along its outer wall, accompanying the internal pudic artery in Alcock's canal, and lying above the vessel. Its further course will be seen in the uro-genital triangle.

The Perineal Nerve.—This nerve is the largest of the three divisions of the pudic nerve. It also passes through the ischio-rectal fossa along its outer wall, accompanying the internal pudic artery in Alcock's canal, and lying below that vessel.

In the fore part of the ischio-rectal fossa the perineal nerve breaks up into three divisions, which enter the uro-genital triangle. These branches are—

- Cutaneous branches—
  - The internal superficial perineal nerve.
  - The external superficial perineal nerve.
- Muscular branches to the superficial perineal muscles.
- Visceral branch to the bulb of the penis.

The Perineal Branch of the Fourth Sacral Nerve.—The anterior primary division of the fourth sacral nerve gives off, in the pelvis, three visceral branches and three muscular branches to the levator ani, the coccygeus, and the external sphincter ani. As the last is the only one of the three muscular branches which enters the perineum, it is termed the perineal branch of the fourth sacral nerve.

This nerve enters the ischio-rectal fossa between the levator ani and coccygeus muscles, or by piercing one of these muscles near the coccyx, and ends by supplying the external sphincter ani. The nerve also gives off cutaneous branches to the skin between the anus and the coccyx.

The Perforating Cutaneous Nerve of the Sacral Plexus.—This nerve, which is derived from the second and third nerves of the sacral plexus, is so named because it is one of the few examples in the body of a nerve piercing a ligament.

It enters the posterior part of the ischio-rectal fossa by piercing the great sacro-sciatic ligament close to the coccyx, and, turning round the lower edge of the gluteus maximus muscle, it is distributed to the skin of the buttock.

The Fat.—The fatty tissue which occupies the ischio-rectal fossa is continuous with the more superficial and fatty layer of the superficial perineal fascia over the uro-genital triangle.

It extends upwards on either side of the rectum, between that viscus and the tuber ischii, forming a lateral elastic support for the lower end of the rectum, which it keeps closed by its pressure, and which on account of its elasticity permits of the distension of the rectum during defæcation.

The deficient vascular supply of this fatty tissue in the ischio-rectal fossa, and its dependent position, render it very liable to abscess formation—ischio-rectal abscess, and its resulting condition, fistula in ano.

The Ano-Coccygeal Body.—The ano-coccygeal body is an indefinite mass of muscular and fibrous tissue which lies between the tip of the coccyx and the anus. It is best seen in sagittal sections through the pelvis.

II. **The Anterior or Uro-Genital Triangle.**—The anterior or uro-genital triangle corresponds almost exactly to the pubic arch, and corresponds in extent with the triangular ligament which fills up that arch.

The uro-genital triangle is bounded *behind* by the imaginary line drawn between the two ischial tuberosities; the apex is *in front* and is formed by the symphysis pubis and the subpubic ligament; *laterally* it is bounded by the conjoined rami of the pubis and ischium.

The uro-genital triangle is subdivided by the triangular ligament into two pouches, one below the triangular ligament—the superficial perineal pouch; the other above it—the deep perineal pouch.

The Perineal Fascia.—The perineal fascia over the uro-genital triangle consists, as is usual throughout the body, of a superficial and a deep layer, with, however, this important difference, that each layer consists of two strata, as follows:—

The superficial perineal fascia.	1. An unnamed fatty layer. 2. A membranous layer, the fascia of Colles.
The deep perineal fascia.	1. The triangular ligament. 2. The parietal pelvic fascia.

The Superficial Perineal Fascia.—The superficial perineal fascia consists, over the uro-genital triangle, of two layers which differ in their character and relations.

1. *The Unnamed Subcutaneous Fatty Layer.*—This layer is continuous with the ordinary superficial fascia of other regions.

In front it passes onwards into the scrotum, loses its fat, contains involuntary muscular fibres, and is there termed the *dartos* muscle. When traced onwards to the abdominal wall it is found to become continuous with that layer of the superficial fascia of the abdomen which is known as the *fascia of Camper.*

Laterally this fascia becomes continuous with the superficial fascia on the inner aspects of the thighs.

Posteriorly it becomes continuous with the fat which has been seen occupying the ischio-rectal fossa.

2. *The Fascia of Colles.*—The fascia of Colles, the deeper and more membranous layer of the superficial perineal fascia, is of more limited extent. It does not, like the unnamed fatty layer, extend backwards over the rectal triangle, but is strictly confined to the anterior or uro-genital triangle, and establishes connections with the abdominal fascia, as will be presently seen. In general outline the fascia of Colles is somewhat triangular, having almost exactly the shape of the uro-genital triangle, with which, in fact, it corresponds.

The base of the fascia of Colles stretches from one ischial tuberosity to the other, and in consequence corresponds almost exactly to the imaginary line which subdivides the anatomical perineum into its two triangles.

Its base is recurved from below upwards round the posterior border of the two transverse perineal muscles, and becomes firmly attached to the base or posterior free border of the triangular ligament.

The lateral margins of the fascia of Colles are firmly fixed on either side to the rami of the pubis and ischium just external to the lines of attachment of the crura penis and the erectores penis muscles, and extend as far back as the ischial tuberosities.

The apex of the fascia of Colles is directed forwards, and

after passing through the scrotum as the dartos muscle it becomes continuous, a little in front of the symphysis with the fibrous covering of the penis, and eventually with that layer of the superficial fascia of the abdomen which is known as the *fascia of Scarpa.*

From the deep surface of this fascia a septum extends upwards in the middle line which divides the subjacent space and the scrotum into two. The septum is deficient anteriorly.

As the attachments of the fascia of Colles explain the course taken by an effusion of urine, in rupture of the urethra, they must not only be carefully studied but must be thoroughly understood.

The Superficial Perineal Pouch.—The superficial perineal pouch is that part of the uro-genital triangle of the perineum which lies below the triangular ligament. This pouch is open in front where it communicates freely with the scrotum.

The superficial perineal pouch is bounded superficially or *below* by the fascia of Colles; *above,* or at its deeper limit, by the triangular ligament; *on either side* by the attachments of both these layers of fascia to the rami of the pubis and ischium; *behind,* by the blending of the recurved base of the fascia of Colles with the base of the triangular ligament.

The terms employed here refer, as they should do, *to the body in the erect attitude,* and not to the position of the part as dissected.

The contents of the superficial perineal pouch are as follows:—

Muscles. The six superficial perineal muscles.
    The accelerator urinæ muscles.
    The erector penis muscles.
    The transverse perineal muscles.
Vessels.
    The superficial perineal artery.
    The transverse perineal artery.
    The termination of the internal pudic artery.
Nerves.
    The superficial perineal nerves.

The long pudendal nerve, or the nerve of Soemmerring.

Muscular branches of the perineal nerve.

Visceral branch of the perineal nerve.

Other Structures.

The root of the penis comprising the bulb and the two crura.

The central point of the perineum.

The Accelerator Urinæ or the Bulbo-Cavernosus Muscles.—These two muscles, which unite in such a way as apparently to form a single unpaired muscle, are situated in front of the external sphincter ani on each side of the middle line. Resting upon, and clothing the bulb of the urethra which they conceal, they extend from the bulb to the neighbourhood of the symphysis pubis.

Origin.—By fleshy fibres from the central point of the perineum and the ano-bulbar median raphé.

Insertion.—From this origin the fibres sweep outwards and forwards on the surface of the corpus spongiosum of the penis.

The *posterior* and shortest fibres are inserted into the superficial or inferior surface of the triangular ligament.

The *intermediate* and most numerous fibres entirely surround the corpus spongiosum, and are inserted into a median tendinous raphé on its dorsal or superior surface.

The *anterior* and longest fibres surround both the corpus spongiosum and the corpora cavernosa of the penis, and are inserted into its dorsal surface. At this spot these fibres of the muscle rest upon and enclose the dorsal vein of the penis.

Nerve Supply.—The perineal branch of the pudic nerve.

The Erector Penis or the Ischio-Cavernosus Muscles.—These are two small elongated muscles situated upon the ischio-pubic rami concealing and surrounding the crura of the penis.

Origin.—From the inner part of the ischial tuberosity and from the ramus of the ischium behind and on each side of the attachment of the crus penis.

Insertion.—Into the crus penis near its anterior part by an aponeurotic tendon.

Nerve Supply.—The perineal branch of the pudic nerve.

The Transverse Perineal Muscles.—*Origin.*—From the internal surface of the ischial tuberosity between the attachments of the erector penis and obturator internus muscles.

Insertion.—From this origin the muscle passes forwards and inwards to be inserted into the ano-bulbar raphé around the central point of the perineum.

Nerve Supply.—The perineal branch of the pudic nerve.

Relations.—The transverse perineal muscles constitute the base of a triangle, *the ischio-bulbar triangle,* the two other sides of which are formed by the accelerator urinæ and erector penis muscles.

The posterior borders of these transverse perineal muscles correspond to the division between the uro-genital and rectal triangles of the anatomical perineum, and round this border the recurved base of the fascia of Colles passes to be attached to the base of the triangular ligament.

These two muscles conceal the base of the triangular ligament.

The Superficial Perineal Artery.—This artery, a branch of the internal pudic artery, arises at the anterior part of the ischio-rectal fossa, opposite the internal surface of the ischium. Piercing the inner wall of Alcock's canal and the base of the triangular ligament, it enters the superficial perineal pouch. Running above or below the transverse perineal muscle, the vessel passes forwards between the accelerator urinæ and erector penis muscles, supplying both, and finally terminates at the posterior part of the scrotum, which it supplies, by anastomosing with the external pudic arteries from the femoral artery. It is accompanied by the superficial perineal nerves.

The Transverse Perineal Artery.—This vessel usually arises in common with the preceding, although occasionally it is a distinct branch from the internal pudic artery. It runs inwards towards the central point of the perineum, and, after supplying the parts between the anus and the bulb, anastomoses with its fellow of the opposite side.

The Termination of the Internal Pudic Artery.—The internal pudic artery terminates in the anterior part of the superficial perineal pouch by dividing into the dorsal artery of the penis and the artery to the corpus cavernosum.

The Superficial Perineal Nerves.—These nerves, two in number, are named internal and external respectively. They are the cutaneous branches of the perineal division of the pudic nerve. Arising from that trunk at the fore part of the ischio-rectal fossa, they enter the superficial perineal pouch by piercing the base of the triangular ligament.

The *external* and smaller of the two nerves passes forwards, accompanied by the superficial perineal artery, to the back of the scrotum, which it supplies. In the ischio-rectal fossa the nerve gives off a cutaneous branch to the skin in front of the anus, which usually communicates with the inferior hæmorrhoidal nerve.

The *internal* and larger of the two nerves runs forwards nearer the middle line than its fellow, and usually passes above the transverse perineal muscle. It breaks up into numerous branches for the supply of the integument of the scrotum.

Both the superficial perineal nerves communicate freely with one another, the external, in addition, communicating with the inferior hæmorrhoidal nerve and the long pudendal from the small sciatic nerve.

The Long Pudendal Nerve.—The long pudendal nerve, or the nerve of Soemmerring, is a branch of the small sciatic nerve. It pierces the fascia lata of the thigh about one inch in front of the ischial tuberosity, and running inwards enters the superficial perineal pouch. It communicates with the external superficial perineal nerve, and ends in the integuments over the outer part of the scrotum.

Muscular Branches from the Perineal Division of the Pudic Nerve.—These branches generally arise by a single trunk from the perineal division of the pudic nerve in the fore part of the ischio-rectal fossa. Entering the superficial perineal pouch, the nerve trunk breaks up into branches which supply all the superficial perineal muscles, and, in addition, the nerve gives branches to the levator ani muscle and occasionally to the external sphincter ani.

Visceral Branch from the Perineal Division of the Pudic Nerve.—This nerve, *the nerve to the bulb*, arises in the same manner as, and very frequently in common with, the last-mentioned nerves. It is a long, slender nerve, which passes inwards, piercing the accelerator urinæ muscle to reach the bulb of the penis, which it supplies. Some of its terminal filaments pierce the corpus spongiosum and supply the mucous membrane of the urethra.

The two last-mentioned nerves, the muscular and visceral branches of the perineal division of the pudic nerve, are frequently referred to as the *deep* branches, as opposed to the cutaneous or *superficial* perineal branches of the perineal division of the pudic nerve.

The Root of the Penis.—Lying below the triangular ligament is the root of the penis, composed of the two crura and the bulb. On tracing these forwards the crura are found to become continuous with the two corpora cavernosa, and the bulb with the corpus spongiosum containing the urethra. These three structures, the two corpora cavernosa and the corpus spongiosum, together constitute the body of the penis; whilst lastly, the anterior extremity of the penis is formed by the glans penis and the prepuce. Thus the penis consists of a middle part or body and two extremities —an anterior extremity or glans penis and a posterior extremity or root of the penis.

The *bulb* of the penis is the expanded and bulbous posterior extremity of the corpus spongiosum containing the urethra. Above it is the triangular ligament, and below it is the accelerator urinæ muscle.

The two *crura* are the divergent posterior extremities of the corpora cavernosa. Each crus is attached to the rami of the pubic arch from the subpubic ligament as far back as the ischial tuberosity. Each crus is concealed by the erector penis muscle.

The posterior extremity, or the root of the penis, as above constituted, is deeply situated in the superficial perineal pouch. It is fixed to the wall of the pelvis partly by means of its two crura, as just indicated, and partly by means of a special ligament—the *suspensory ligament* of the penis.

The Central Point of the Perineum.—This is the term applied to the median part of the ano-bulbar median raphé. It is situated about one inch in front of the anus, just behind the bulb of the urethra in the male and the vagina in the female.

At this point several of the perineal muscles meet; these muscles are—the accelerator urinæ, external sphincter ani, transverse perineal, and levator ani muscles.

The central point of the perineum corresponds to the centre of the base of the triangular ligament, and the bulb with its artery lies just in front of it, therefore in performing the operation of lithotomy the knife should never be entered in front of this spot.

The Deep Perineal Fascia.—The deep perineal fascia, like the superficial perineal fascia, consists of two layers, the triangular ligament and that portion of the parietal pelvic fascia which is in apposition with the deep surface of the triangular ligament.

1. *The Triangular Ligament.*—This ligament, triangular in form, is situated immediately above the superficial perineal muscles and the root of the penis, and exactly fills the pubic arch.

It is a purely adventitious sheet of fascia which fills up the pubic arch in just the same way as the obturator membrane fills up the obturator foramen.

The triangular ligament subdivides the uro-genital triangle into two pouches,—the superficial perineal pouch which lies below the triangular ligament, and the deep perineal pouch which lies above it.

With the body in the erect attitude the triangular ligament is almost parallel with the ground, and may be described as possessing a base, an apex, two lateral borders, and two surfaces—superior and inferior.

The base of the triangular ligament looks backwards and is slightly curved on each side of the central point of the perineum. It corresponds to the transverse perineal muscles, or to the imaginary line dividing the anatomical perineum into its two subsidiary triangles.

The centre of the base of the triangular ligament corres-

ponds to the central point of the perineum, and at this point the triangular ligament measures, from base to apex, one and a half inches.

Attached to the base of the triangular ligament are the recurved base of the fascia of Colles and that part of the parietal pelvic fascia which constitutes the upper boundary of the deep perineal pouch.

The apex of the triangular ligament extends up to, but is not in contact with, the symphysis pubis. The apex is somewhat blunted, and is marked by some transverse fibres, termed the *transverse perineal ligament.* This so-called ligament stretches across the apex of the pubic arch, and together with the subpubic ligament bounds an oval aperture, which transmits the dorsal vein of the penis.

The two lateral borders of the triangular ligament are attached on either side to the ischio-pubic rami.

The superior surface of the triangular ligament looks upwards and slightly backwards, and forms the inferior boundary of a pouch, to be presently described—the *deep perineal pouch.*

The inferior surface of the triangular ligament looks downwards and slightly forwards. It forms the superior boundary of the *superficial perineal pouch,* and is in contact with the root of the penis and the superficial perineal muscles.

Structures which pierce the triangular ligament.—The triangular ligament is pierced by certain structures, which are as follows:—

In the middle line, about one inch behind the symphysis, the urethra pierces the ligament to enter the bulb.

The arteries to the bulb pass downwards on either side of the urethral orifice.

The dorsal nerve of the penis and the internal pudic artery on each side pierce the ligament near its apex and close to the pubic ramus.

Lastly, certain structures, such as the superficial perineal vessels and nerves, pierce the base of the ligament to enter the superficial perineal pouch.

2. *The Parietal Pelvic Fascia.*—The second layer of the

deep perineal fascia is formed by the fascia lining the interior of the pelvis; this is the parietal pelvic fascia. That portion of it which is in apposition with the triangular ligament is sometimes termed the *superior or deep layer of the triangular ligament.*

The Deep Perineal Pouch.—The deep perineal pouch is that part of the uro-genital triangle of the perineum which lies above the triangular ligament. Unlike the superficial perineal pouch, it is an absolutely closed space.

The deep perineal pouch is bounded *below* or superficially by the triangular ligament; *above,* or at its deeper limit, by the parietal pelvic fascia and by the apex of the prostate gland; *on either side,* by the attachments of both these layers of fascia to the rami of the pubis and ischium; *behind,* by the blending of the parietal pelvic fascia with the base of the triangular ligament; *in front,* by the attachments of both layers of fascia to the symphysis pubis.

The contents of the deep perineal pouch are as follows:—

Muscle.
  The compressor urethræ muscle.
Vessels.
  The internal pudic artery.
  The artery to the bulb.
  The dorsal vein of the penis.
Nerves.
  The dorsal nerves of the penis.
Other Structures.
  The membranous or second part of the urethra.
  Cowper's glands.

The Compressor Urethræ Muscle.—This muscle, situated above and in front of the transverse perineal muscles, but separated from them by the triangular ligament, runs transversely across the pubic arch and surrounds the membranous urethra.

Attachments.—The muscular fibres are attached on each side to the ischio-pubic rami. From this attachment the fibres run transversely inwards, passing both in front of, and behind, the membranous urethra, for which they thus form a species of sphincter muscle. Reflex contraction of this

muscle, supervening on gonorrhœa, produces spasmodic stricture of the urethra, and possibly retention of urine.

Nerve Supply.—The dorsal nerve of the penis.

The Internal Pudic Artery.—The internal pudic artery leaves the ischio-rectal fossa, in the outer wall of which it was last seen, and enters the deep perineal pouch of the uro-genital triangle by piercing the base of the triangular ligament.

The vessel then passes forwards between the two layers of the deep perineal fascia, and therefore above the triangular ligament, along the margin of the ischio-pubic rami; near the apex of the pubic arch the vessel pierces the triangular ligament, and so enters the superficial perineal pouch, where it terminates under cover of the crus penis by dividing into its two terminal branches, the dorsal artery of the penis and the artery of the corpus cavernosum.

The Artery to the Bulb.—This comparatively large vessel arises from the internal pudic artery a little in front of the base of the triangular ligament. It passes almost transversely inwards between the fibres of the compressor urethræ muscle, to which it gives branches, and about half an inch in front of the base of the triangular ligament. The vessel then turns downwards, pierces the triangular ligament close to the urethral orifice in that structure, and penetrating the bulb, supplies it as well as the erectile tissue of the corpus spongiosum, the mucous membrane of the urethra, and the glands of Cowper. The artery to the bulb must be carefully studied, as it is liable to injury in the operation of lateral lithotomy.

The Dorsal Artery of the Penis.—This artery, one of the terminal branches of the internal pudic artery, arises from that vessel below the triangular ligament, and is *not* therefore in the perineal pouch under discussion. It reaches the dorsal surface of the penis by passing upwards between the crus penis and the symphysis, and then piercing the suspensory ligament.

The Artery of the Corpus Cavernosum.—This, the second terminal branch of the internal pudic artery, enters the posterior extremity of the corpus cavernosum, and is distributed to the erectile tissue of that body.

The Dorsal Vein of the Penis.—This vein runs backwards between the two dorsal arteries in the median groove on the upper surface of the penis. Passing through the oval aperture left between the transverse perineal ligament (apex of triangular ligament) and the subpubic ligament, the vessel crosses the deep perineal pouch, communicates on each side with the internal pudic veins, and then divides into two parts, which enter the right and left portions of the prostatic venous plexus.

The Dorsal Nerve of the Penis.—This nerve, one of the three main divisions of the pudic nerve, accompanies the internal pudic artery in its course through the ischio-rectal fossa and the deep perineal pouch. It pierces the triangular ligament with that artery, and so entering the superficial perineal pouch is then continued onwards with the dorsal artery of the penis to the glans penis. In its passage through the deep perineal pouch this nerve gives off a branch to the compressor urethræ muscle.

The Membranous or Second Part of the Urethra.—(*See* page 165.)

Cowper's Glands. — Cowper's glands are two small, rounded, whitish structures, situated in the deep perineal pouch above the bulb of the penis and behind the membranous urethra. They lie in the substance of the compressor urethræ muscle on either side of the middle line. Their ducts run forwards in the urethral wall for about one inch, and open into the floor of the third part of the urethra. These glands secrete a viscid fluid, the function of which is unknown.

Synopsis of the Internal Pudic Artery and its Branches. — The various anatomical regions successively traversed by this artery and its branches may be summarised as follows :—

Regions.	*Branches.*	
1. Pelvic cavity.		
2. Buttock (ischial spine).		
3. Ischio-rectal fossa (Alcock's canal).	Inferior hæmorrhoidal. Superficial perineal. Transverse perineal.	
4. Deep perineal pouch . . .	Artery to bulb.	
5. Superficial perineal pouch . .	Artery to corpus cavernosum. Dorsal artery of penis.	Terminal.

Synopsis of the Pudic Nerve.—This nerve, unlike the artery, breaks up into its three terminal branches as soon as it enters the perineum from the pelvis, that is to say, in the small sacro-sciatic foramen. These terminal branches are:—

1. Inferior hæmorrhoidal nerve.
    - (*a*) Cutaneous.
    - (*b*) Muscular.
    - (*c*) Communicating.
2. The dorsal nerve of the penis.
3. The perineal nerve.
    - (*a*) Cutaneous.
        1. Internal superficial perineal nerve.
        2. External superficial perineal nerve.
    - (*b*) Muscular.
        - To the superficial perineal muscles.
    - (*c*) Visceral.
        - To the bulb of the penis.

Alternation of Fasciæ and Muscles in the Region of the Pubic Arch.—It is important to notice, as has been well pointed out by Cunningham, the alternation of fascial and muscular strata in the region of the pubic arch. Thus there are the following strata, in order, from below upwards:—

1. The fascia of Colles.
2. The superficial perineal muscles.
3. The triangular ligament.
4. The compressor urethræ muscle.
5. The parietal pelvic fascia.
6. The levator ani muscle.
7. The capsule of the prostate.

THE FEMALE PERINEUM

In the description of the female perineum it suffices to describe those points in which the female perineum differs from that of the male. The chief differences are to be found in the external anatomy, where the aperture of the vagina and the surrounding vulva occupy the position of the scrotum of the male.

Boundaries.—The boundaries, divisions, and subdivisions of the female perineum correspond to those of the male, but the pelvic outlet is rather larger in the female than in the male.

The Vulva, or the Pudendum.—Under this term are included the external organs of generation of the female. By the external genital organs, or the vulva, are meant those parts which lie below the hymen. The vulva comprises the following parts:—

- The labial folds.
    - The mons veneris.
    - The labia majora.
    - The labia minora.
- The vulval cleft, or the uro-genital space.
    - The vestibule.
    - The meatus urinarius.
    - The hymen.
- The erectile organs.
    - The clitoris.
    - The vestibular bulbs.

The Mons Veneris.—The mons veneris is the eminence covered with adipose tissue and numerous hairs, which is situated in front of the upper part of the symphysis pubis.

The Labia Majora.—The labia majora are two elongated folds of skin, extending downwards and backwards from the mons veneris to within about one inch of the anus. Each labium consists of an inner and an outer surface and two extremities.

The *external* surface of each labium majus is convex and resembles ordinary skin, being covered with hairs. The *internal* surface is usually in contact with its fellow of the opposite side, and in this way the two labia majora conceal from view the remaining parts of the vulva. In old persons, however, the labia minora frequently project beyond the labia majora so as to be visible externally.

The *anterior extremities* of the labia majora unite to form the anterior commissure of the vulva. The anterior com-

missure of the vulva is thick and rounded, and becomes continuous with the lower part of the mons veneris. The *posterior extremities* of the labia majora unite to form the posterior commissure.

The labia majora correspond to the scrotum of the male.

The Labia Minora.—The labia minora, or the nymphæ, are two narrow pendulous folds of skin lying just internal to the labia majora.

Their *external* surfaces are in contact with the internal surfaces of the labia majora, and their internal surfaces with each other.

The *anterior extremity* of each labium minus divides into two parts, the more anterior and longer of which passes in front of the clitoris and forms the *preputium clitoridis.* The more posterior and the shorter of the two parts passes to the posterior part of the clitoris, and forms the *frænulum clitoridis.*

The *posterior extremity* of each labium minus may terminate by blending with the internal surface of the labium majus, but more frequently it becomes continuous with a transverse fold of skin situated at the anterior edge of the perineal body, and termed the *fourchette,* or the *frænulum pudendi.* Between the fourchette and the hymen there is a small space termed the *fossa navicularis.*

The labia minora and the fourchette differ from the labia majora in being devoid of fat.

The Vulval Cleft or the Uro-genital Space.—The vulval cleft is the median fissure which lies between the labia. It may be divided into two parts—an anterior part, the vestibule; and a posterior part, the vaginal orifice.

The Vestibule.—The vestibule constitutes the anterior part of the uro-genital space. It is somewhat triangular in outline and has the following boundaries:—

The base is formed by an imaginary line drawn through the meatus urinarius. The apex is situated at the clitoris. The two lateral boundaries are formed, on either side, by the labia minora.

The Meatus Urinarius.—The meatus urinarius is the termination of the urethra. It is situated one inch behind the clitoris, near the anterior wall of the vagina, and on the imaginary line which is drawn through it to form the base of the vestibule.

The Hymen.—The orifice of the vagina is guarded, in the virgin, by a fold of mucous membrane termed the hymen. In rare cases the hymen forms a complete partition between the vagina and the vulva, giving rise to the condition known as "imperforate hymen." In women who have borne children the hymen is usually replaced by some small rounded elevations, termed the *carunculæ myrtiformes.*

The Clitoris.—The clitoris is the homologue of the penis, and is an erectile organ, consisting of two corpora cavernosa and a rudimentary glans clitoridis.

Posteriorly, the two corpora cavernosa diverge from each other and form the crura clitoridis, which are attached to the rami of the pubis, and are covered by the erector clitoridis muscles.

The glans of the clitoris is an imperforate, highly sensitive structure, which is surrounded by the prepuce of the clitoris and the frænulum clitoridis, both formed by the labia minora. Both the body and the glans of the clitoris are composed of spongy erectile tissue.

The clitoris differs from the penis in being much smaller, and in not being traversed by the urethra.

The Vestibular Bulbs.—The vestibular bulbs constitute the remaining portion of the erectile tissue in the female. Each bulb is about one inch long, and lies in the lateral walls of the uro-genital cleft, below the triangular ligament.

The Superficial Perineal Muscles.—The superficial muscles of the female perineum are as follows—

The transverse perineal muscles.
The erector clitoridis muscles.
The sphincter vaginæ muscle.

The first two muscles correspond to the transverse perineal and erector penis muscles of the male, whilst the two halves of the elliptical sphincter vaginæ muscle appear to correspond to the accelerator urinæ muscles of the male perineum.

The Sphincter Vaginæ Muscle.—This muscle is an orbicular muscle surrounding the orifice of the vagina, and

corresponding to the accelerator urinæ muscles of the male perineum.

Origin.—From the central point of the perineum, in common with the external sphincter ani, and the transverse perineal muscles.

Insertion.—From the foregoing origin the muscular fibres sweep round the orifice of the vagina and the vestibule, to be inserted mainly into the corpora cavernosa of the clitoris.

Action.—This muscle constricts the orifice of the vagina.

Nerve Supply.—The perineal branch of the pudic nerve.

The Triangular Ligament.—The triangular ligament is not so well marked as in the male. In the female it transmits the vagina, in addition to the other structures mentioned under the male perineum.

The Compressor Urethræ Muscle.—This muscle lies in the deep perineal pouch, and corresponds to the compressor urethræ muscle of the male perineum. It only differs from the compressor urethræ muscle of the male in being almost completely divided into two parts by the vagina.

The Glands of Bartholin.—The glands of Bartholin are peculiar to the female, they correspond to the glands of Cowper in the male. They lie in the deep perineal pouch, close to the posterior extremities of the bulb of the vestibule, and are covered by the sphincter vaginæ muscle. These glands are two elongated structures about half an inch in length; their ducts open, one on each side, into the groove on the lateral surface of the vagina, between the attachment of the hymen and that of the labium minus.

The Internal Pudic Artery and Nerve.—The internal pudic artery terminates by dividing into the dorsal artery of the clitoris, and the artery of the corpus cavernosum, whilst the pudic nerve similarly gives off the dorsal nerve of the clitoris, corresponding to the dorsal nerve of the penis of the male perineum.

The Perineal Body.—The perineal body is an indefinite mass of fibrous and muscular tissue which occupies the restricted interval between the fourchette and the anus. In midwifery it is frequently termed simply "the perineum"; it is therefore of some practical importance to carefully note the difference in meaning of the word "perineum" as used in human anatomy and in midwifery. In the former case it denotes the whole outlet of the pelvis, in the latter a very small portion only of that space.

II. THE ABDOMINAL WALL

The Superficial Fascia.—Over the anterior abdominal wall there is only one layer of fascia; this corresponds to the superficial fascia of other regions.

In the upper part of the anterior abdominal wall this layer of fascia is thin and weak, and consists of a single layer only. Above, it is directly continuous with the superficial fascia over the chest.

In the lower part of the abdomen the superficial fascia divides into two layers—a superficial layer called the *fascia of Camper*; and a deeper and more membranous layer, the *fascia of Scarpa.* If these two divisions of the superficial fascia of the abdominal wall be traced downwards towards Poupart's ligament, it will be noticed that the *fascia of Camper* passes uninterruptedly downwards in front of Poupart's ligament to become continuous with the superficial fascia of the thigh. The *fascia of Scarpa* is a membranous and elastic layer which passes downwards in front of Poupart's ligament, and immediately blends with the deep fascia of the thigh, that is, with the fascia lata. Internally, near the external abdominal ring, the fascia of Scarpa is prolonged downwards in front of the spermatic cord to the scrotum, but elsewhere it blends with the fascia lata of the thigh along a line drawn horizontally outwards from the inner end of Poupart's ligament. In the lower part of the abdominal wall the separation between the two layers of superficial fascia is very distinct, and is made by the superficial vessels, such as the superficial epigastric vessels which run between the fascia of Camper and that of Scarpa. The fascia of Scarpa corresponds to the tunica abdominalis of some of the lower animals.

The Deep Fascia.—The deep fascia is entirely absent over the anterior abdominal wall.

Cutaneous Nerves.—These are arranged in two series, anterior and lateral, on the same plan as the cutaneous nerves of the thorax. In the abdomen these cutaneous nerves are as follows:—

Anterior series—
- The anterior cutaneous nerves.
- The hypogastric branch of the ilio-hypogastric nerve.
- The ilio-inguinal nerve.

Lateral series—
- The lateral cutaneous nerves.
- The iliac branch of the last dorsal nerve.
- The iliac branch of the ilio-hypogastric nerve.

The Anterior Cutaneous Nerves.—The anterior cutaneous nerves are the terminal cutaneous filaments of the lower dorsal nerves, from the seventh to the twelfth inclusive. They pierce the sheath of the rectus abdominis muscle at somewhat variable distances from the middle line of the body, and then turn outwards in the superficial fascia. The branches from the seventh dorsal nerve emerge near the lower end of the ensiform cartilage, those from the tenth usually supply the skin near the umbilicus, and those from the twelfth (last dorsal nerve) are distributed below a point midway between the umbilicus and the pubis.

The Hypogastric or Abdominal Branch of the Ilio-Hypogastric Nerve.—This nerve becomes cutaneous by piercing the aponeurosis of the external oblique muscle a little above the external abdominal ring. It supplies the skin of the abdomen above the pubis.

The Ilio-Inguinal Nerve.—The ilio-inguinal nerve emerges at the external abdominal ring on the outer side of the spermatic cord. It supplies the skin of the pubic region and scrotum in the male, and the labium pudendi in the female. It also supplies the skin of the upper and inner parts of the thigh.

The Lateral Cutaneous Nerves of the Abdomen.—The lateral cutaneous nerves of the abdomen are the lateral cutaneous branches of the seventh to the eleventh intercostal nerves (both inclusive). They become superficial between the digitations of the external oblique muscle in a line a little behind the anterior or pectoral border of the axilla. They divide into anterior and posterior divisions.

The *anterior divisions* run downwards and inwards nearly to the edge of the rectus abdominis muscle; the *posterior divisions* pass backwards over the latissimus dorsi muscle.

The Iliac Branch of the last Dorsal Nerve.—The iliac or lateral cutaneous branch of the last dorsal nerve is usually of considerable size, but does *not* divide into anterior and posterior branches, and is *not* confined to the abdominal wall.

It becomes cutaneous by piercing the external oblique muscle at a variable distance above the iliac crest, usually from one to three inches above that point. The nerve then runs downwards over the iliac crest, one and a half inches behind the anterior superior iliac spine, and supplies the skin of the buttock as far down as the great trochanter.

The Iliac Branch of the Ilio-Hypogastric Nerve.—This nerve becomes cutaneous by piercing the external oblique muscle close to the iliac crest about the junction of its middle and anterior thirds, or opposite the tubercle of the crest of the ilium. It supplies the skin of the buttock.

Cutaneous Vessels.—Three sets of cutaneous arteries are found in the abdominal wall.

First, a series of vessels accompanying the lateral cutaneous nerves; these are derived from the aortic intercostal arteries.

Second, a series of vessels accompanying the anterior cutaneous nerves; these are derived from the aortic intercostal arteries, and from the superior and deep epigastric arteries.

Third, a series of vessels from the common femoral artery, namely, the superficial pudic artery, the superficial epigastric artery, and the superficial circumflex iliac artery. The veins accompanying this series of superficial arteries terminate in the long saphenous vein in the thigh.

The Muscles of the Abdominal Wall.—There are five pairs of muscles in the abdominal wall. These are as follows:—

The external oblique muscles.

The internal oblique muscles.
The transversalis abdominis muscles.
The rectus abdominis muscles.
The inconstant pyramidalis muscles.

The External Oblique Muscle.—*Origin.*—This large muscle arises by eight digitations from the outer surfaces and lower borders of the eight lower ribs, near their cartilages. The upper five slips interdigitate with the digitations of the serratus magnus muscle, the lower three with those of the latissimus dorsi muscle.

Insertion.—From this extensive origin the muscular fibres pass generally downwards and inwards to be inserted partly by fleshy muscular fibres and partly by an extensive aponeurosis, as follows:—

(*a*) The most posterior fibres pass almost vertically downwards to be inserted into the anterior half of the outer lip of the iliac crest by fleshy muscular slips.

(*b*) All the remaining muscular fibres pass more or less obliquely downwards and inwards, to be inserted by a large aponeurosis which is wider below than above, as follows:—

Into the whole length of Poupart's ligament.
Into one inch of the ilio-pectineal line of the same side, by means of Gimbernat's ligament.
Into the front of the symphysis pubis.
Into one inch of the ilio-pectineal line of the *opposite* side by means of the triangular fascia.
Into the whole length of the linea alba.

The Aponeurosis of the External Oblique Muscle is a structure of the highest practical importance, and it must receive the most careful attention from the student. An aponeurosis may be defined as being a tendon of insertion which has become flattened out.

In connection with the aponeurosis of the external oblique muscle, the following points must be noted:—

1. The size and extent of the aponeurosis.
2. Poupart's ligament.
3. Gimbernat's ligament.
4. The external or superficial abdominal ring.
5. The triangular fascia.

6. The intercolumnar or external spermatic fascia.
7. The linea alba.
8. The lineæ transversæ.
9. The linea semilunaris.

1. *The Size and Extent of the Aponeurosis.*—The aponeurosis of the external oblique is of considerable size. It is wider below than above, and its external margin may be indicated by a line drawn from the ninth costal cartilage to a point a little internal to the anterior superior iliac spine.

2. *Poupart's Ligament.* — This important structure is merely the lower edge of the aponeurosis of the external oblique folded upon itself. It extends from the anterior superior spine of the ilium to the spine of the pubis. It is somewhat curved, with the convexity downwards, but this convexity only exists so long as the fascia lata of the thigh remains attached to the ligament; when that structure is cut through, this curve disappears. The outer half of the ligament is somewhat oblique, and the inner half is horizontal, and is situated in front of the femoral vessels.

Attached to Poupart's ligament there are the following muscles:—The internal oblique muscle, the transversalis abdominis muscle, and in the male the cremaster muscle.

The various layers of fasciæ attached to the ligament are:—The fascia of Scarpa to the inner end of the ligament only, the fascia lata of the thigh, the fascia iliaca of the abdomen, the transversalis fascia of the abdomen, the ilio-pectineal fascia, and Gimbernat's ligament.

3. *Gimbernat's Ligament.*—This is a reflection backwards from the inner end of Poupart's ligament to the ilio-pectineal line. It is a triangular structure possessing a base, an apex, an anterior border, a posterior border, a superior surface, and an inferior surface.

The base of the ligament is sharp, crescentic, and free, and forms the internal boundary of the crural ring; hence it has a most important relation to the anatomy of femoral hernia, as it is against this part of the ligament that the hernia most frequently becomes strangulated.

The apex of the ligament is situated at the pubic spine.

The anterior border is attached to Poupart's ligament,

while the posterior border is attached to one inch of the ilio-pectineal line.

The superior surface looks upwards and slightly inwards, and if taken in conjunction with Poupart's ligament forms a species of groove upon which the spermatic cord lies; the inferior surface looks downwards and slightly outwards.

4. *The External or Superficial Abdominal Ring.*—This important aperture constitutes the outlet of the inguinal canal. It is an evagination of the aponeurosis of the external oblique muscle, and is only seen as a distinct hole after the external spermatic fascia, which is prolonged downwards into the scrotum from its margins, has been removed. Under such conditions the so-called ring will be seen to be triangular, possessing a base, an external pillar, and an internal pillar.

The base of the ring is formed by the crest of the pubis, the external pillar is formed by the inner end of Poupart's ligament, while the internal pillar is formed by the aponeurosis of the external oblique muscle itself.

It must be particularly noted that the base of the ring lies altogether internal to the spine of the pubis, consequently an inguinal hernia will descend internal to the pubic spine, whereas a femoral hernia descends external to the pubic spine.

The external abdominal ring is larger in the male than in the female. Its average length is about one inch, its breadth about half an inch, but its size varies considerably.

It transmits, in the male, the spermatic cord, the ilio-inguinal nerve, and the fibrous remains of the processus vaginalis peritonei; and in the female the round ligament of the uterus, the ilio-inguinal nerve, and possibly the canal of Nuck. The round ligament becomes lost in the superficial fascia in the neighbourhood of the groin; whilst the canal of Nuck is the remains of a pouch of peritoneum which descends for a variable distance upon the round ligament.

5. *The Triangular Fascia.*—This is a thin layer of fascia, very infrequently present and of absolutely no importance. In fact, it is much open to question if it has any existence whatsoever. It is described as forming the means by which the aponeurosis of the external oblique gains its insertion

into the ilio-pectineal line of the *opposite* side. It passes from the linea alba to the inner inch of the ilio-pectineal line, and is there situated immediately behind Gimbernat's ligament. In order to expose the triangular fascia, the internal pillar of the ring must be removed.

6. *The Intercolumnar or External Spermatic Fascia.*—The fibres of which this structure is composed are chiefly found in the neighbourhood of the anterior superior spine of the ilium; they bind together the two pillars of the ring, and are prolonged down upon the spermatic cord as the external spermatic fascia.

7. *The Linea Alba.*—The linea alba is a white, fibrous structure situated in the middle line of the abdominal wall, and extending from the ensiform process of the sternum to the symphysis pubis. It is formed by the union of the external and internal oblique muscles and the transversalis abdominis muscles of the two sides, and gives insertion in a very large measure to these muscles. A little below its middle the linea alba broadens out into a circular space, in the centre of which is the cicatrix of the *umbilicus.*

On account of the comparative non-vascularity of the linea alba it is a favourite site for exploratory incisions into the abdomen. The linea alba becomes much increased in breadth during pregnancy, or by any abdominal disease characterised by distension.

8. *The Lineæ Transversæ.*—The lineæ transversæ are transverse lines in the aponeurosis of the external oblique muscle which are produced by the Inscriptiones Tendineæ of the rectus abdominis muscle.

9. *The Linea Semilunaris.*—The linea semilunaris is the white curved line or depression situated in the aponeurosis of the external oblique muscle on each side opposite the outer border of the subjacent rectus abdominis muscle. It corresponds to the place where the aponeurosis of the internal oblique muscle splits to enclose the rectus abdominis muscle.

Nerve Supply of the External Oblique.—The anterior primary divisions of the six lower dorsal nerves.

Action.—This muscle constricts the abdominal cavity and

compresses the enclosed viscera; it may also act as a muscle of forced expiration.

Relations.—The external oblique muscle is superficial throughout, with the exception of a small part posteriorly, which is overlapped by the latissimus dorsi muscle. The fibres of the external oblique run generally downwards and inwards, but the most posterior fibres descend almost vertically from the last rib to the iliac crest; hence the posterior border of the muscle is free, and forms one of the boundaries of the *triangle of Petit.*

This triangle is bounded as follows:—In front by the posterior free margin of the external oblique muscle, behind by the latissimus dorsi muscle; the base is formed by the iliac crest. This triangle is of some practical importance, as a lumbar hernia may make its appearance here.

The Internal Oblique Muscle.—*Origin.*—The internal oblique muscle arises as follows:—

1. From the outer half or two-thirds of Poupart's ligament.
2. From the anterior two-thirds of the middle lip of the crest of the ilium.
3. From the posterior lamella of the lumbar aponeurosis, that is, from the posterior aponeurosis of the transversalis abdominis muscle.

Insertion.—From this origin the fibres of the muscle pass, generally upwards and inwards, to be inserted by means of an extensive aponeurosis, as follows:—

Into the cartilages of the lower six ribs.

Into the linea alba.

The lowest fibres arch downwards and inwards from their origin from Poupart's ligament to be inserted into the crest of the pubis, and the inner half-inch of the ilio-pectineal line behind Gimbernat's ligament.

The Aponeurosis of the Internal Oblique Muscle, like that of the external oblique, is of the highest practical importance, and must be carefully studied.

It extends from the margin of the thorax to the pubis, and is wider above than below. In the greater part of its extent this aponeurosis divides into two layers at the outer edge of the rectus abdominis muscle. This division into two layers extends from the ninth costal cartilage to a point midway between the umbilicus and the symphysis pubis.

Between these two points the *anterior lamella of the aponeurosis* of the internal oblique passes to the linea alba in front of the rectus muscle, and becomes inseparably blended with the aponeurosis of the external oblique, thus forming the anterior part of the sheath of the rectus muscle.

The *posterior lamella of the aponeurosis* of the internal oblique passes to the linea alba behind the rectus, and, becoming similarly inseparably blended with the aponeurosis of the transversalis abdominis muscle, forms the posterior part of the sheath of the rectus.

Above the level of the ninth costal cartilage the *posterior lamella of the aponeurosis* of the internal oblique is attached to the eighth and seventh costal cartilages, and to the ensiform process, while the *anterior lamella* is prolonged upwards to the chest with the aponeurosis of the external oblique.

Below a point midway between the umbilicus and the symphysis pubis, that is, about the level of the anterior superior iliac spine, the aponeurosis of the internal oblique, together with the aponeuroses of the external oblique and transversalis abdominis muscles, pass altogether in front of the rectus abdominis muscle. The deficiency thus resulting in the *posterior* wall of the sheath of the rectus forms a well-marked semilunar edge, termed the *Semilunar Fold of Douglas.*

The study of that portion of the aponeurosis of the internal oblique muscle which takes part in the formation of the conjoined tendon is best deferred until after the examination of the transversalis abdominis muscle and its aponeurosis.

Nerve Supply.—The anterior primary divisions of the six lower dorsal nerves, the ilio-hypogastric, and the ilio-inguinal nerves.

Action.—The same as the external oblique muscle.

Relations.—The various vessels and nerves which run round the abdominal wall lie between the internal oblique and transversalis abdominis muscles, and their presence in this plane must be noted.

The lower border of the internal oblique muscle has very important relations to the spermatic cord. It arches over the cord in such a way that, externally, those fibres of the muscle which arise from Poupart's ligament lie *in front of* the cord and the internal abdominal ring; but internally those fibres of the muscle which are inserted into the crest of the pubis and the ilio-pectineal line, and which assist in the formation of the *conjoined tendon*, lie *behind* the cord and the external abdominal ring. This peculiar relation of conjoined tendon to external abdominal ring thus materially strengthens an otherwise weak spot in the abdominal parietes.

The Nerves of the Abdominal Wall.—The nerves which run through the abdominal wall lie, for the most part, between the internal oblique and transversalis abdominis muscles. The nerves are as follows:—

The lower or abdominal intercostal nerves, the seventh to the eleventh inclusive.

The last dorsal nerve.

The ilio-hypogastric nerve, from the lumbar plexus.

The ilio-inguinal nerve, from the lumbar plexus.

The Lower or Abdominal Intercostal Nerves.—The lower or abdominal intercostal nerves are the anterior primary divisions of the seventh to the eleventh dorsal nerves inclusive.

In the first part of their course they have the same relations as the upper or pectoral intercostal nerves.

At the anterior part of the intercostal spaces they enter the abdominal wall by passing between the slips of origin of the diaphragm. They then run forwards between the internal oblique and transversalis abdominis muscles as far as the edge of the rectus abdominis, when they pierce the posterior part of the sheath of that muscle, and, turning forwards through both the rectus and its sheath, terminate as the anterior cutaneous nerves already described.

Midway between the spine and the linea alba they give off the *lateral cutaneous nerves.* They also supply muscular branches to the two obliques, transversalis and rectus abdominis muscles, and to the serratus posticus inferior—a muscle of the back.

The Last Dorsal Nerve.—This nerve, the anterior primary division of the twelfth dorsal nerve, enters the abdominal cavity behind the external arcuate ligament of the diaphragm.

It lies immediately below the last rib and passes outwards in front of the quadratus lumborum muscle accompanied by the abdominal branch of the first lumbar artery, as far as the outer border of the quadratus lumborum, where it pierces the lumbar aponeurosis, and so gains the interval between the internal oblique and transversalis abdominis muscles, after which it pursues the same course as the intercostal nerves.

This nerve supplies muscular branches to the internal and external oblique, transversalis, rectus and pyramidalis muscles, and terminates as one of the *anterior cutaneous nerves* of the abdomen. Its *lateral cutaneous branch* crosses the iliac crest to become a cutaneous nerve of the buttock.

The Ilio-Hypogastric Nerve.—This nerve, a branch of the first lumbar nerve, makes its appearance at the upper part of the outer border of the psoas muscle, from whence it runs outwards in front of the quadratus lumborum muscle, and, piercing the transversalis abdominis muscle near the iliac crest, gains the interval between the internal oblique and transversalis abdominis muscles, between which it divides into an *iliac* branch and a *hypogastric or abdominal* branch, the latter of which continues the main direction of the nerve as far as a point just above the external abdominal ring, where it becomes cutaneous.

It supplies the internal oblique and transversalis abdominis muscles.

The Ilio-Inguinal Nerve.—This nerve is also derived from the first lumbar nerve, but is smaller than the ilio-hypogastric nerve.

It lies immediately below that nerve and pursues an almost similar course. It becomes superficial by passing through the external abdominal ring.

The ilio-inguinal nerve gives off no lateral cutaneous branch, but furnishes muscular filaments to the internal oblique and transversalis abdominis muscles, and terminates as a cutaneous nerve of the scrotum and thigh.

The Transversalis Abdominis Muscle.—*Origin.*—This

muscle has a triple origin—a costal origin, a vertebral origin, and a pelvic origin, as follows:—

1. A *costal* origin, from the deep surfaces of the six lower rib cartilages by slips which interdigitate with the costal attachments of the diaphragm.

2. A *vertebral* origin, by means of the *posterior* aponeurosis of the transversalis abdominis muscle or the *lumbar aponeurosis,* from the bodies, transverse processes, and spines of the lumbar vertebræ.

3. A *pelvic* origin, from the anterior two-thirds of the inner lip of the crest of the ilium, and from the outer third of Poupart's ligament.

Insertion.—The muscular fibres run, generally transversely inwards to be inserted by means of the *anterior* aponeurosis, as follows:—

Into the linea alba.
Into the pubic crest and the inner inch of the ilio-pectineal line, behind Gimbernat's ligament and the insertion of the internal oblique muscle.

The transversalis abdominis muscle differs from the other abdominal muscles in two important respects—first, its fibres run almost horizontally inwards; and, secondly, it possesses *two* aponeuroses, anterior and posterior.

The *posterior* aponeurosis of the transversalis abdominis muscle is more usually known as the *lumbar aponeurosis*; it extends from the last rib above to the ilio-lumbar ligament and iliac crest below. It consists of three layers, known as the anterior, middle, and posterior lamellæ respectively of the lumbar aponeurosis.

The *anterior lamella* is attached to the bodies of the lumbar vertebræ close to the pedicles.

The *middle lamella* is attached to the tips of the transverse processes of the lumbar vertebræ, and also extends inwards between them to be attached to their contiguous borders.

The *posterior lamella* is attached to the tips of the spines of the lumbar vertebræ and the intervening supraspinous ligaments. This lamella gives origin to the internal oblique, latissimus dorsi, and serratus posticus inferior muscles.

Between the three lamellæ of the lumbar aponeurosis two compartments are formed, anterior and posterior.

The *posterior compartment* lodges the erector spinæ muscle.

The *anterior compartment* lodges the quadratus lumborum muscle.

The *anterior* aponeurosis of the transversalis abdominis is again of supreme practical importance. It extends from within one inch of the outer edge of the rectus abdominis muscle to the linea alba, and is widest in the middle of its extent.

In the upper two-thirds of its extent it lies behind the rectus abdominis, and, fusing with the posterior lamella of the aponeurosis of the internal oblique, forms the posterior part of the sheath of the rectus, as has already been pointed out. In the lower third of its extent it lies, like all the other layers, altogether in front of the rectus muscle, and it is this portion which forms part of the conjoined tendon.

The Conjoined Tendon.—This important structure must receive the most careful study on account of its great surgical significance. It is formed by the fusion, in the inguinal region, of the aponeuroses of the internal oblique and transversalis abdominis muscles, and it will be well to recall the attachments of these two muscles in this region.

The internal oblique is attached to the crest of the pubis and the inner *half-inch* of the ilio-pectineal line.

The transversalis abdominis muscle is attached to the crest of the pubis and to the inner *inch* of the ilio-pectineal line, hence it is obvious that the transversalis takes the greater part in the formation of the conjoined tendon. If the disposition of these layers, as regards the rectus muscle, has been noted, it will be further obvious that the conjoined tendon lies in front of the rectus muscle and behind Gimbernat's ligament.

Nerve Supply.—The same as the internal oblique.

Action.—As before.

Relations.—The inner or deep surface of this muscle is lined throughout by the fascia transversalis of the abdomen, which separates it from the extraperitoneal fat and the peritoneum.

Above, it is continuous with the triangularis sterni muscle.

The Rectus Abdominis Muscle.—*Origin.*—The rectus abdominis muscle is a long flat muscle, which arises from the pubic crest and the symphysis pubis.

Insertion.—The muscle passes upwards to be inserted into the cartilages of the fifth, sixth, and seventh ribs, that is, into the cartilages of the three lower true ribs.

Nerve Supply.—The anterior primary divisions of the lower six dorsal nerves.

Action.—The same as the other abdominal muscles.

Relations.—The rectus abdominis muscle is, in the greater part of its course, enclosed in what is termed the *sheath of the rectus.* The manner and arrangement of this structure have already been pointed out.

The *posterior* surface of the rectus muscle successively rests upon—

The cartilages of the three lower true ribs.

The posterior part of the sheath of the rectus. Upon that part of the sheath which is formed by the posterior lamella of the aponeurosis of the internal oblique. This holds good as far as a point midway between the umbilicus and the symphysis pubis.

Below the point indicated, the posterior surface rests upon the fascia transversalis of the abdomen.

In front of the rectus muscle there are from above downwards—

The fused lamellæ of the aponeurosis of the external oblique and the anterior lamella of the aponeurosis of the internal oblique.

Below the point already indicated there will be in front of the rectus the aponeuroses of the external oblique, the internal oblique, and the transversalis abdominis muscles.

The *inner* edge of the rectus is only separated from that of its fellow by the linea alba.

The *outer* edge of the rectus corresponds to the linea semilunaris.

The substance of the rectus is intersected by three irregular intersections, termed the *Inscriptiones Tendineæ.* These are most frequently situated—one opposite the umbilicus, a second opposite the ensiform cartilage, and a third midway between the other two.

Contents of the Sheath of the Rectus.—The sheath of the rectus contains the rectus and pyramidalis muscles, the superior and deep epigastric arteries, and the seventh to the eleventh intercostal nerves inclusive, together with the last dorsal nerve.

The Pyramidalis Muscle.—*Origin.*—The pyramidalis is an inconstant muscle, which when present arises from the crest of the pubis, and is contained in the sheath of the rectus.

Insertion.—Into the linea alba.

Nerve Supply.—The last dorsal nerve.

The Fascia Transversalis.—The abdominal cavity is lined throughout by a sheet of fascia which receives different names in different portions of its extent. That portion of this abdominal fascial lining which is in contact with the deep surface of the transversalis abdominis muscle is termed the *Fascia transversalis.* It separates the deep surface of that muscle from the extraperitoneal fat and the peritoneum.

Attachments. — The various attachments of the fascia transversalis are numerous and important. *Internally,* the fascia transversalis passes uninterruptedly across the deep surface of the linea alba.

Externally, the fascia transversalis passes round the lateral wall of the abdomen to become continuous with the psoas fascia on the posterior wall of the abdomen. In the lateral wall of the abdomen the fascia transversalis is usually tacked down to the inner lip of the crest of the ilium, and there becomes continuous with that portion of the general abdominal fascial lining which is termed the *Fascia iliaca,* and which is found in the region of the iliac fossa.

Above, the fascia transversalis is very thin. It becomes uninterruptedly continuous with the thin fascia on the abdominal or inferior surface of the diaphragm.

Below, the fascia transversalis is very strong, and its attachments in the neighbourhood of Poupart's ligament are of the greatest practical importance. These important

attachments may here be conveniently subdivided into three parts:—

(a) External to the femoral vessels.
(b) In front of the femoral vessels.
(c) Internal to the femoral vessels.

(a) *External to the femoral vessels* the fascia transversalis is attached to Poupart's ligament from the anterior superior iliac spine as far inwards as the femoral vessels. In this portion of its extent it is again continuous with the fascia iliaca.

(b) *In front of the femoral vessels* the fascia transversalis ceases to be attached to Poupart's ligament. It passes uninterruptedly downwards, behind Poupart's ligament and in front of the femoral vessels, into the thigh, forming there the anterior part of the femoral sheath. That part of the fascia transversalis which here lies directly behind Poupart's ligament is specially thickened and is hence sometimes specially named—the *deep crural arch.*

(c) *Internal to the femoral vessels* the fascia transversalis passes downwards to be attached to the ilio-pectineal line and the pubic bone. This part of the fascia transversalis lies immediately behind the conjoined tendon.

In the dissection of the anterior abdominal wall the only places where the fascia transversalis is visible from the front are,—firstly, in the small interval which exists between the arched lower border of the transversalis abdominis muscle and Poupart's ligament; and, secondly, behind the rectus abdominis muscle from the semilunar fold of Douglas downwards to the pubis.

In the former situation the spermatic cord, in the process of the descent of the testicle, pushes the fascia transversalis before it. The point at which the fascia transversalis is so evaginated is termed the *internal abdominal ring*; whilst the tubular covering which is prolonged from the fascia at this point, downwards upon the spermatic cord, is termed the *infundibuliform or internal spermatic fascia.*

The Inguinal Canal.—The inguinal canal is the oblique passage formed in the anterior abdominal wall by the testicle, in its descent from the abdominal cavity into the scrotum.

The inguinal canal may be described as possessing an entrance, the canal itself, and an exit, as follows:—

An entrance, the internal or deep abdominal ring.
The inguinal canal itself.
An exit, the external or superficial abdominal ring.

The Internal or Deep Abdominal Ring.—This is the point where the fascia transversalis of the abdomen is evaginated by the passage through it of the testicle. It is situated half an inch above Poupart's ligament, and midway between the anterior superior iliac spine and the symphysis pubis. Almost immediately below the internal abdominal ring, but separated therefrom by Poupart's ligament, is the external iliac artery, whilst the deep epigastric artery lies first below, and then to the inner side of the ring.

The Inguinal Canal.—The inguinal canal extends from the internal or deep abdominal ring to the external or superficial abdominal ring. It is one and a half inches in length, and passes inwards and very slightly downwards and forwards immediately above and parallel to the inner half of Poupart's ligament. The boundaries of the canal, which are of the highest importance, are as follows:—

In front.
  The aponeurosis of the external oblique muscle throughout the whole extent of the canal.
  The internal oblique muscle at the outer end of the canal.
Behind.
  The fascia transversalis throughout the whole extent of the canal.
  The conjoined tendon at the inner end of the canal.
  The triangular fascia, also at the inner end.
Above.—The arched lower borders of the internal oblique and transversalis abdominis muscles.
Below.
  Poupart's ligament.
  Gimbernat's ligament.

The contents of the canal are, in the male, the spermatic cord, the ilio-inguinal nerve, and the fibrous remains of the *processus vaginalis peritonei.*

In the female the canal is much smaller. Its contents are the round ligament of the uterus, the ilio-inguinal nerve, and the remains of an analogous process of peritoneum termed the *canal of Nuck.*

The External or Superficial Abdominal Ring.—This has already been fully considered under the external oblique muscle of the abdomen. (*See* page 29.)

The Deep Arteries of the Abdominal Wall.—The deep arteries of the abdominal wall must not be confused with the superficial arteries already described. (*See* page 26.) The deep arteries of the abdominal wall are derived from various sources, and may be classified according to the direction which they take, as follows:—

Running downwards.

The superior epigastric artery	From the internal mammary artery.
The musculo-phrenic artery .	

Running forwards.

The last two intercostal arteries, from the descending thoracic aorta.

The abdominal branches of the lumbar arteries, from the abdominal aorta.

Running upwards.

The deep epigastric artery .	From the external iliac artery.
The deep circumflex iliac artery	

The Superior Epigastric Artery.—The superior epigastric artery is one of the two terminal branches of the internal mammary artery. It commences at the sixth intercostal space, and passes downwards in the sheath of the rectus; in the substance of that muscle the vessel terminates by anastomosing with the deep epigastric artery from the external iliac.

The Musculo-phrenic Artery.—The musculo-phrenic artery is the other terminal branch of the internal mammary artery. It runs downwards and outwards along the costal margin, and can only be seen by reflecting the transversalis abdominis muscle from its attachment to the costal cartilages. It anastomoses with the aortic intercostal arteries of the seventh, eighth, and ninth intercostal spaces.

The last two Intercostal Arteries.—The aortic intercostal arteries in the tenth and eleventh intercostal spaces pass downwards and forwards in the abdominal wall between the internal oblique and transversalis abdominis muscles. They anastomose with the vertical arterial chain formed by the superior and deep epigastric arteries.

The Abdominal Branches of the Lumbar Arteries.—These vessels are the abdominal representatives of the thoracic intercostal arteries. They pass forwards between the same muscles, and anastomose anteriorly with the deep epigastric artery, and below with the deep circumflex iliac and iliolumbar arteries.

The Deep Epigastric Artery.—This important vessel arises from the external iliac artery just above Poupart's ligament. It first lies in the extraperitoneal fat, and courses inwards between the internal abdominal ring and Poupart's ligament; it then passes upwards to the inner side of the internal abdominal ring, and is here crossed, in the male, on its outer side, by the vas deferens and spermatic vessels, and in the female by the round ligament of the uterus. The artery then pierces the fascia transversalis, and, passing in front of the semilunar fold of Douglas, enters the sheath of the rectus. It terminates in the substance of the rectus muscle by anastomosing with the superior epigastric artery from the internal mammary.

Some of the relations of this vessel are of the greatest surgical importance, and should therefore be specially noted. These important practical relations may be summarised as follows:—

1. The deep epigastric artery lies, at its origin, first below and then to the inner side of the internal abdominal ring.

2. As the deep epigastric artery passes upwards and inwards from its origin below the internal abdominal ring it crosses the outer part of the inguinal canal posteriorly. It is therefore only separated from the spermatic cord in the inguinal canal by the fascia transversalis.

3. The vas deferens, as it emerges from the inguinal canal into the abdominal cavity at the internal abdominal ring, hooks round from the outer to the inner side of the artery.

4. An oblique inguinal hernia leaves the abdominal cavity external to the deep epigastric artery, and is therefore sometimes termed an *external inguinal hernia.*

5. A direct inguinal hernia leaves the abdominal cavity internal to the deep epigastric artery, and is therefore sometimes termed an *internal inguinal hernia.*

6. The deep epigastric artery forms the external boundary of a triangle to be presently described—*Hesselbach's triangle.*

The Branches of the deep epigastric artery are as follows :—

1. Cremasteric.
2. Pubic.
3. Cutaneous.
4. Muscular.

The *cremasteric artery* is a small vessel which descends in the spermatic cord and supplies the cremaster muscle and the other coverings of the cord.

The *pubic artery* passes downwards to the deep surface of the body of the pubis, where it anastomoses with a pubic branch of the obturator. This vessel abnormally replaces the obturator artery in two out of every five subjects, and then becomes of considerable practical importance in connection with the surgery of femoral hernia. An obturator artery arising abnormally from the deep epigastric artery is termed the *aberrant obturator.* It passes downwards into the pelvis to reach the upper part of the obturator foramen, through which it is transmitted to the thigh.

In this course the aberrant obturator may pass backwards and downwards external to the crural ring, or immediately above the crural ring; or, in about one out of every eighty cases, internal to the crural ring. In the last two instances an aberrant obturator is in danger of being severed in the operation for the relief of a strangulated femoral hernia, and therefore the possibility of the presence of this vessel must always be borne in mind.

The *cutaneous branches* of the deep epigastric artery pass forwards to anastomose with the superficial epigastric artery.

The *muscular branches* supply the rectus abdominis muscle.

The Deep Circumflex Iliac Artery.—This vessel also arises from the external iliac artery just above Poupart's ligament.

It lies first in the extraperitoneal fat, and runs outwards and upwards behind Poupart's ligament as far as the anterior superior iliac spine.

The vessel then pierces the fascia transversalis, and, taking the crest of the ilium as its guide, runs outwards between the fascia transversalis and the transversalis abdominis muscle.

Lastly, it pierces the transversalis abdominis opposite the middle of the iliac crest, and ends by anastomosing with the iliac branch of the ilio-lumbar artery.

Very frequently this vessel gives off, opposite the anterior superior iliac spine, a large unnamed branch which runs upwards between the internal oblique and transversalis abdominis muscles to anastomose with the epigastric and lumbar arteries.

The Scrotum.—The scrotum forms the investment for the testicles and for part of the spermatic cords. The coverings of the testicle and spermatic cord within the scrotum, and therefore the walls of the scrotum itself, are as follows:—

The skin.
The dartos muscle.
The external spermatic fascia, derived from the external oblique muscle.
The cremasteric fascia, derived from the internal oblique muscle.
The internal spermatic or infundibuliform fascia, derived from the fascia transversalis.
The tunica vaginalis, derived from the peritoneum.

The Skin of the Scrotum.—The skin of the scrotum is thin and of a darker colour than that of the body generally. It is traversed along the middle line by a median raphé or ridge, which is a sufficient indication of its originally bilateral character.

The Dartos Muscle.—The muscular sheet, to which the name "*dartos*" is given, is the continuation, into this region, of the superficial fascia of the abdomen (the fascia of Camper and the fascia of Scarpa).

Posteriorly, it becomes continuous with the superficial perineal fascia over the anterior or uro-genital triangle (the unnamed fatty layer, and the fascia of Colles).

Laterally, it becomes continuous with the superficial fascia of the thigh. The so-called dartos muscle is then merely a layer of superficial fascia containing muscular fibres. It is of a peculiar reddish-brown colour, and is contractile.

The superficial fascia of the scrotum, or the dartos muscle, forms, in the interior of the scrotum, an imperfect septum, which divides its interior into two compartments, one for each testicle. The skin is therefore the only covering common to *both* testicles.

The External Spermatic Fascia.—The external spermatic fascia is the covering given to the testicle and cord by the external oblique muscle. It is, therefore, attached above to the margins of the external abdominal ring, and is prolonged downwards upon the cord and testicle.

The Cremasteric Fascia.—The cremasteric fascia is the musculo-membranous covering given to the testicle and cord by the internal oblique muscle of the abdomen.

The purely muscular portion of this layer is termed the *cremaster muscle*; it takes the form of a series of loops, attached by one extremity to the inner end of Poupart's ligament, and by the other to the spine and crest of the pubis; the intermediate fibres form a series of successively lengthening loops, which descend in front of the spermatic cord as low as the testicle. This muscle is peculiar to the male.

The various muscular loops are connected together by means of a membranous tissue; and to the entire sheet, of muscle and membrane, the name *cremasteric fascia* is applied.

The Infundibuliform or Internal Spermatic Fascia.—This covering is derived from the fascia transversalis of the abdomen, and becomes continuous with that structure at the internal abdominal ring.

The Tunica Vaginalis.—The tunica vaginalis is the serous covering of the testicle. It is derived from the peritoneum, and is the remains of that tubular prolongation of peritoneum which passes downwards from the abdomen into the scrotum in advance of the descent of the testicle. The tunica vaginalis is the simplest of all serous membranes, and consists of a parietal and a visceral layer.

The *parietal or scrotal layer* of the tunica vaginalis is more extensive than the visceral layer, passing upwards for some little distance upon the spermatic cord, but rather higher on the inner than on the outer side.

The *visceral portion* of the tunica vaginalis, or the *tunica vaginalis testis,* surrounds the body of the testicle and the epididymis, except at the posterior border of the testicle, where the vessels and nerves enter or leave that viscus, and where the visceral layer becomes continuous with the parietal layer of the tunica vaginalis. On the outer surface of the organ, and between the epididymis and the body of the testicle, the tunica vaginalis testis is depressed in the form of a pouch—the *digital fossa.*

The Vascular Supply of the Scrotum—The arterial supply of the scrotum is derived from the superficial and deep external pudic arteries from the femoral artery; from the superficial perineal artery, a branch of the internal pudic; and from the cremasteric branch of the deep epigastric artery.

The veins of the scrotum accompany the arteries.

The Nerves of the Scrotum.—The nerves of the scrotum, like the arteries, are derived from several sources. The nerves are as follows:—The ilio-inguinal nerve; the superficial perineal branches of the pudic nerve; the long pudendal branch of the small sciatic, and the genital branch of the genito-crural nerve.

The Spermatic Cord.—The spermatic cord extends from the internal abdominal ring to the testicle. From the internal abdominal ring the cord passes obliquely through the inguinal canal to the external abdominal ring, and, emerging through that aperture, descends almost vertically to the testicle.

The coverings of the cord have already been described; its contents are as follows:—

The vas deferens.

Arteries.
  The spermatic artery, from the abdominal aorta.
  The cremasteric artery, from the deep epigastric artery.
  The artery to the vas deferens, from either the superior or inferior vesical arteries.
Veins.
  The veins accompany the arteries, forming the spermatic or pampiniform plexus.
Nerves.
  The genital branch of the genito-crural nerve.
  Filaments from the sympathetic.
Lymphatics and areolar tissue.

The Vas Deferens.—The vas deferens, or the excretory duct of the testicle, commences at the lower end of the epididymis. It passes at first almost vertically upwards along the inner side of the epididymis and back of the testicle, and then along the posterior part of the spermatic cord to the external abdominal ring. The vas deferens then runs outwards and slightly backwards and upwards in the inguinal canal to the internal abdominal ring, where it leaves the other constituents of the spermatic cord and, hooking round the deep epigastric artery, enters the pelvis. (*See* page 159.) The vas deferens terminates in the prostatic portion of the urethra.

If the scrotum be firmly grasped between the finger and thumb, the vas deferens is very easily recognised by its hard, firm, whip-cord-like character.

The Spermatic Artery.—The spermatic artery is a branch of the abdominal aorta. It enters the cord at the internal abdominal ring, and the testicle at its posterior border.

The Cremasteric Artery.—The cremasteric artery is a branch of the deep epigastric artery.

The Artery to the Vas Deferens.—The artery to the vas deferens arises in the pelvis from either the superior or inferior vesical arteries. It enters the cord at the internal abdominal ring, and accompanies the vas deferens as far as the testicle. This vessel also gives off minute branches to the intrapelvic portion of the vas deferens.

The Spermatic or Pampiniform Venous Plexus. — The spermatic or pampiniform venous plexus is a bulky venous plexus found in the spermatic cord. The spermatic veins issue from the posterior border of the testicle, and are then replaced by the plexus. From the upper end of this plexus the single vein—the spermatic vein—reappears, and, entering the abdomen at the internal abdominal ring, terminates on the right side in the inferior vena cava, and on the left side in the left renal vein.

A varicose condition of this venous plexus of the spermatic cord gives rise to the surgical condition known as *varicocele.*

The Genital Branch of the Genito-Crural Nerve.—The genital branch of the genito-crural nerve enters the spermatic cord at the internal abdominal ring. It supplies the cremaster muscle in the male, but in the female the nerve is very small, and terminates in the round ligament and the labium pudendi.

The Sympathetic Filaments.—The sympathetic filaments accompany the spermatic artery. They are derived from the renal and aortic sympathetic plexuses within the abdomen. They enter the cord at the internal abdominal ring.

The Lymphatic Vessels.—The lymphatic vessels leave the spermatic cord and enter the abdomen at the internal abdominal ring. They terminate in the lumbar glands.

The Testicles.—The testicles are the two principal reproductive glands of the male. They are suspended obliquely in the scrotum, by means of the spermatic cord and its coverings, in such a way that the upper end of the testicle is directed forwards and outwards. The left testicle is usually rather lower than the right. The vas deferens constitutes the excretory duct for each testis.

Each testicle is oval in shape, and is somewhat compressed laterally. They present, for examination, two surfaces, external and internal; two borders, anterior and posterior; and two extremities, superior and inferior.

The External Surface.—The external surface looks outwards and slightly backwards. It is smooth and convex, and covered throughout by the tunica vaginalis testis.

The Internal Surface.—The internal surface looks inwards

and slightly forwards. It is covered throughout by the tunica vaginalis testis, and is more nearly flat than is the external surface.

The Anterior Border.—The anterior border of the testicle is convex and smooth, and is covered throughout by the tunica vaginalis testis.

The Posterior Border.—The posterior border of the testicle is attached to the spermatic cord, and at this part of the testicle the various vessels and nerves enter or leave it. Attached to the posterior border, and overlapping to a slight extent the posterior part of the external surface of the testicle, is the *epididymis,* a structure to be immediately described.

The Inferior Extremity.—The inferior extremity of the testicle corresponds to its most dependent part. It gives attachment to a musculo-fibrous sheet—the *scrotal ligament of the testicle*—which passes from thence to the scrotum, and serves, to a slight extent, to maintain the testicle in position.

The Superior Extremity.—The superior extremity of the testicle is overlapped by the *globus major* of the epididymis. Between this structure and the upper end of the testicle there are frequently two minute pedunculated bodies, the *hydatids of Morgagni,* which are the remains of a fœtal structure, Müller's duct. One of these hydatids is usually pear-shaped, whilst the other is generally sessile and smaller.

The Epididymis.—The epididymis is a long narrow body forming part of the excretory apparatus of the testicle. It rests upon the posterior border of the testicle, and to a slight extent overlaps the posterior part of the external surface. The epididymis consists of three parts—an enlarged upper extremity, the head or the *globus major*; an intermediate portion, the *body*; and a lower, more pointed portion, the tail, or the *globus minor.*

The *globus major* surmounts the upper end of the testicle, to which it is directly attached by means of the *vasa efferentia,* which pass to it from the testicle.

The *body of the epididymis* extends from the globus major above to the globus minor below. It lies quite freely against the posterior border of the testicle, from which it is separated by that portion of the tunica vaginalis testis which dips inwards at this point to form the *digital fossa.*

The *globus minor* is quite loosely attached to the lower part of the posterior border of the testicle by areolar tissue. The vas deferens emerges from the lower end of the globus minor, and then passes upwards along the posterior border of the testicle on the inner side of the epididymis. This relation serves to refer a testicle to the side to which it belongs.

Structure of the Testis.—The testicle is enclosed in a very strong fibrous capsule, the *tunica albuginea.* At the posterior border of the gland this fibrous covering forms an elongated column, the *corpus Highmori,* or the *mediastinum testis.* From this, numerous fibrous bands pass through the substance of the testicle, subdividing its interior into a number of compartments containing the secretory apparatus of the gland.

The spermatic fluid is secreted in the body of the testicle in the tubuli seminiferi; from this it successively passes through the following structures:—

1. The tubuli recti.
2. The rete vasculosum testis.
3. The vasa efferentia.
4. The coni vasculosi.
5. The convoluted canal of the epididymis.
6. The vas deferens.

By the vas deferens the spermatic fluid is conveyed to the common ejaculatory duct, which opens into the prostatic urethra.

The Vascular Supply of the Testicle.—The arterial supply of the testicle is derived from the spermatic artery, a branch of the abdominal aorta.

The veins form the *spermatic or pampiniform* plexus, from whence the spermatic veins pass onwards, to terminate, on the right side, in the inferior vena cava, and, on the left, in the left renal vein.

The Nervous Supply of the Testicle.—The nerves of the testicle are derived from the spermatic plexus of the sympathetic.

The Descent of the Testicle.—It is important to remember that the testicle is placed, at an early period of intra-uterine life, within the abdomen, and not within the scrotum. The testicle only comes to assume its permanent position within the scrotum by means of certain changes, which together constitute what is termed the *descent of the testicle.*

During the greater part of intra-uterine life the testicle lies within the abdomen. It rests on the psoas muscle, against the posterior wall of the abdomen, immediately below the lower end of the kidney, and altogether behind the peritoneum.

Before the testicle commences to descend from its fœtal position on the posterior abdominal wall, a tubular process of peritoneum passes from the abdomen through the inguinal canal into the scrotum; this tubular process of peritoneum is termed the *processus vaginalis peritonei,* and by its means the peritoneal cavity communicates—during the later months of fœtal life—quite freely with the scrotum. This processus vaginalis, as well as the testicle itself, is stated to be drawn downwards into the scrotum by means of a muscle termed the *gubernaculum testis.*

As soon as the processus vaginalis has passed from the abdomen, through the inguinal canal, into the scrotum, there commences the descent of the testicle itself. It is most important to notice that the testicle does not descend *inside* the processus vaginalis, but *behind* it. As soon as the downward movement of the testicle has commenced, that body begins to slip down the posterior abdominal wall *behind* the peritoneum, until, at the seventh month of intra-uterine life, the testicle has reached the internal abdominal ring. During the eighth month it traverses the inguinal canal, lying behind the processus vaginalis, and at the ninth month it has reached its final position within the scrotum.

During its downward course the testicle slightly invaginates the most posterior portion of the processus vaginalis peritonei in front of it. This invaginated portion of the processus vaginalis is termed the *mesorchium,* and eventually becomes the visceral layer of the tunica vaginalis.

At this stage, therefore, of intra-uterine life—that is, just about or immediately prior to birth—the testicle is lying at the bottom of the scrotum with a tubular prolongation of peritoneum in front of it. This tubular process communicates freely with the general peritoneal cavity, and forms the processus vaginalis peritonei.

As soon as the testicle has reached its permanent position in the scrotum the cavity of the processus vaginalis commences to obliterate. The process of obliteration commences at the internal abdominal ring, and gradually proceeds until the whole of the cavity of the processus vaginalis has disappeared, with the exception of its lower or scrotal end, which remains as the *tunica vaginalis testis.* The intermediate portion of the processus vaginalis, from the internal abdominal ring to the upper end of the tunica vaginalis of the testicle, remains only as a small minute fibrous cord, which lies in front of the spermatic cord. Even this is not always to be found, nor does it always extend so far downwards as stated.

A knowledge of the changes by which the descent of the testicle is accomplished is of the highest practical importance, as without such knowledge it is impossible to appreciate the various pathological conditions which may occur.

Should the processus vaginalis, for example, not commence to obliterate as soon as the descent of the testicle is successfully accomplished, then the infant is born with an open tubular communication between the general abdominal cavity and the scrotum. The intestine readily passes downwards *inside* this peritoneal tube into the scrotum, and the child suffers from *congenital inguinal hernia.*

Even should obliteration of the processus vaginalis have commenced, hernia may still result. If the obliteration commences at the internal abdominal ring, and only partially progresses, or even not at all, that form of hernia known as *infantile hernia* may ensue. In this case a second tubular process of peritoneum containing the hernia is pushed down through the internal abdominal ring, either into the partially closed processus vaginalis or behind it.

Should obliteration of the processus vaginalis have pro-

ceeded so far at the time of birth as to make it impossible for a hernia to ensue, there are still other pathological conditions which may result from imperfect or incomplete obliteration of the processus vaginalis. One of these is *encysted hydrocele of the cord.* In this case the processus vaginalis becomes completely obliterated above and below, but in its intermediate portion remains patent; the filling of this intermediate patent portion with fluid gives rise to the pathological condition under consideration.

The Penis. — The penis consists of three parts: a posterior extremity, or the root of the penis; an intermediate portion, or the body; and an anterior extremity, or the glans penis.

Each of these three parts is in its turn composed of certain structures, as follows:—

The root of the penis—
1. The bulb of the penis.
2. The two crura of the penis.

The body of the penis—
3. The corpus spongiosum.
4. The two corpora cavernosa.

The anterior extremity—
5. The glans penis.
6. The prepuce.

The Root of the Penis.—The root of the penis constitutes that part which is attached to the triangular ligament and to the ischio-pubic rami. It is situated in the superficial perineal pouch in the anterior or uro-genital triangle of the perineum, and consists of a central portion, the *bulb*; and two lateral portions, the *crura* of the penis.

The Bulb of the Penis.—The bulb of the penis is the expanded and bulbous posterior extremity of the *corpus spongiosum.* It lies in the middle line immediately below the triangular ligament, and therefore in the superficial perineal pouch. It is concealed by the accelerator urinæ muscle, contains the urethra, and is composed of erectile tissue.

The Two Crura of the Penis.—The two crura are the backward and diverging prolongations of the two *corpora* *cavernosa* of the body of the penis. They lie below the rami of the pubic arch, to which they are attached, and are there concealed by the erector penis muscles. Like the bulb of the penis, they lie in the superficial perineal pouch.

The Body of the Penis.—The body of the penis consists of the two *corpora cavernosa* situated dorsally, and continuous posteriorly with the two crura, and the *corpus spongiosum* situated ventrally, and continuous posteriorly with the bulb of the penis.

The Corpus Spongiosum.—The corpus spongiosum extends forwards from the bulb as a cylindrical or slightly tapering body, lying in the groove below and between the two corpora cavernosa; it becomes continuous, in front, with the glans penis, and contains the urethra. It is composed of erectile tissue, but never becomes quite so much distended with blood as do the corpora cavernosa.

The two Corpora Cavernosa.—The two corpora cavernosa constitute the principal part of the body of the penis. They have the form of two cylindrical bodies placed side by side, and diverge posteriorly, to become continuous with the two crura of the root of the penis.

The two corpora cavernosa are separated from each other by a fibrous septum, termed the *septum pectiniforme,* and, like the corpus spongiosum, they are composed of erectile tissue.

On their dorsal surface there is a slight groove, which lodges the dorsal vein of the penis, and which, near the root of the penis, is attached to the symphysis pubis by means of the *suspensory ligament of the penis.*

The Anterior Extremity of the Penis.—The anterior extremity of the penis is composed of the slightly enlarged terminations of the corpora cavernosa and the corpus spongiosum—the glans penis, and of a reflection of skin, termed the prepuce.

The Glans Penis.—The glans penis is compressed from above downwards, and has, at its extremity, the vertical orifice of the *meatus urinarius.* Its base receives the anterior extremities of the two corpora cavernosa, and the corpus spongiosum. The projecting border of the glans penis is

usually termed the *corona glandis*, behind which is the neck of the penis.

The Prepuce. — The prepuce is the reflection of skin which covers, either partially or entirely, the glans penis. On the under surface of the glans penis there is a slight fold —the *frænum præputii*—which extends from the lower angle of the meatus urinarius to the prepuce.

The Suspensory Ligament of the Penis. — The suspensory ligament of the penis is a strong triangular elastic band which connects the penis to the symphysis pubis. It is attached by one border to the symphysis pubis, and to the penis by two lamellæ which join the body of that organ, and between which the dorsal vessels and nerves are situated.

The Vascular Supply of the Penis.—On the dorsal surface of the penis, on either side of the middle line, are the two dorsal arteries of the penis, derived from the internal pudic arteries. The bulb of the penis is, in addition, supplied by the arteries to the bulb from the two internal pudic arteries.

The venous return from the penis is principally by means of its dorsal vein, which is situated upon the dorsal surface, exactly in the middle line. This vein passes backwards just below the symphysis pubis, and through the interval between the blunted apex of the triangular ligament and the subpubic ligament, into the prostatic venous plexus.

The Nerves of the Penis.—The nerves of the penis are the dorsal nerves of the penis, from the pudic nerves; these nerves lie upon the dorsal surface of the penis, just external to the corresponding arteries.

The superficial perineal nerves from the pudic nerves, and filaments from the hypogastric plexus of the sympathetic, also supply the penis.

The Deep Surface of the Anterior Abdominal Wall. —After having opened into the abdominal cavity it is necessary to examine the parietal peritoneum on the deep surface of the anterior abdominal wall, and, in addition, certain important structures which lie in the extra-peritoneal fat in front of the peritoneum, and which will consequently be seen shining through the peritoneum when viewed from behind.

The structures which lie in front of the peritoneum, and which will be seen through the peritoneum when viewed from behind, are:—

1. Poupart's ligament.
2. The deep epigastric artery. } Hesselbach's triangle.
3. The outer edge of the rectus muscle.
4. The obliterated hypogastric artery.
5. The urachus.
6. The obliterated umbilical vein.

The points to be specially noted in connection with the peritoneum itself are:—

1. The external inguinal fossa, containing the internal or deep abdominal ring.
2. The middle inguinal fossa.
3. The internal inguinal fossa.
4. The femoral fossa.
5. The superior false ligament of the bladder.
6. The falciform ligament of the liver.

Hesselbach's Triangle.—Immediately behind the inner end of the inguinal canal there is, in the anterior abdominal wall, a very definite triangular area which is known as *Hesselbach's triangle.*

As the boundaries of Hesselbach's triangle are of some practical importance in connection with the surgery of inguinal hernia, they must be carefully studied.

The boundaries of Hesselbach's triangle are:—

Below. The inner half of Poupart's ligament.
Externally. The deep epigastric artery.
Internally. The outer border of the rectus muscle.

Subdivision of Hesselbach's Triangle.—Hesselbach's triangle is usually crossed by the *obliterated hypogastric artery,* a structure which passes from the internal iliac artery on the posterior wall of the pelvis to the apex of the bladder and thence on to the umbilicus. The obliterated hypogastric artery crosses Hesselbach's triangle in such a way as to divide it into two very unequal and very varying portions. That portion of Hesselbach's triangle which lies to the inner

side of the obliterated hypogastric artery usually lies behind, and corresponds to, the conjoined tendon.

The Urachus.—The urachus is a musculo-fibrous cord, which may or may not be seen, passing from the apex of the bladder to the umbilicus. It is situated in the middle line of the body between the right and left obliterated hypogastric arteries, which similarly pass from the apex of the bladder to the umbilicus.

The urachus and bladder are the remains of the fœtal allantois.

The Obliterated Umbilical Vein.—The obliterated umbilical vein, or the round ligament of the liver, is a fibrous cord which lies in the lower border of the falciform ligament of the liver, and extends from the umbilicus to the inferior surface of the liver. Its precise connections are considered with the liver.

The Peritoneal Fossæ.—In the neighbourhood of the region already described as forming Hesselbach's triangle, the peritoneum forms certain well-marked depressions which are known as the *Peritoneal fossæ.* These fossæ are four in number:—

(*a*) The external inguinal fossa.
(*b*) The middle inguinal fossa.
(*c*) The internal inguinal fossa.
(*d*) The femoral fossa.

(*a*) *The External Inguinal Fossa.*—The external inguinal fossa lies immediately external to the deep epigastric artery. It contains the internal or deep abdominal ring, which forms the deepest part of the fossa.

In the male the various structures which form the spermatic cord converge upon the internal abdominal ring, and in the female the round ligament of the uterus leaves the abdominal cavity at the same place.

An external or oblique inguinal hernia leaves the abdomen at the internal abdominal ring in the external inguinal fossa.

(*b*) *The Middle Inguinal Fossa.*—The middle inguinal fossa lies immediately behind the outer portion of Hesselbach's triangle. It has very definite boundaries, as follows:—

Below. Poupart's ligament.
Externally. The deep epigastric artery.
Internally. The obliterated hypogastric artery.

The middle inguinal fossa is usually the best marked of the three.

(c) *The Internal Inguinal Fossa.*—The internal inguinal fossa lies between the obliterated hypogastric artery on its outer side, and the urachus on its inner side. It usually lies behind the conjoined tendon.

An internal or direct inguinal hernia usually leaves the abdomen through either the middle or internal inguinal fossæ, but more frequently through the latter.

(d) *The Femoral Fossa.*—Below the external inguinal fossa, and separated therefrom by Poupart's ligament, there is not infrequently a fourth slight peritoneal fossa termed the *Femoral fossa.* It indicates the position of the crural or femoral ring, which lies between the sharp free edge or base of Gimbernat's ligament on the inner side, and the external iliac or femoral vein on the outer side. The femoral fossa is better marked in the female than in the male, and is limited externally by the vas deferens or the round ligament of the uterus, according to the sex.

The Superior False Ligament of the Bladder.—This is the double fold of peritoneum which is raised off the anterior abdominal wall by the urachus and the two obliterated hypogastric arteries. It is situated in the middle line of the body, and extends from the apex of the bladder to the umbilicus.

The Falciform Ligament of the Liver.—The falciform ligament of the liver is the double fold of peritoneum which is raised off the anterior abdominal wall by the passage of the obliterated umbilical vein from the umbilicus to the under surface of the liver. The ligament is fully described with the liver.

Inguinal Hernia.—In order to understand the important surgical subject of inguinal hernia, it is imperative for the student to be familiar with the normal anatomy of the parts concerned. The following parts should therefore be most carefully revised :—

1. The attachments of the aponeuroses of the external and internal oblique muscles of the abdomen, and of the transversalis abdominis muscle.
2. The boundaries and extent of the inguinal canal.
3. The descent of the testicle.
4. Hesselbach's triangle and the associated peritoneal fossæ.

Varieties of Inguinal Hernia.—Two forms of inguinal hernia are described, the differentiation between the two being made either by considering the part of the inguinal canal which the hernia first enters, or by indicating its relation to the deep epigastric artery. Thus an inguinal hernia which enters the inguinal canal at the internal abdominal ring just external to the deep epigastric artery is termed an *oblique or external inguinal hernia,* — *oblique,* because it traverses the whole length of the inguinal canal obliquely through the anterior abdominal wall; *external,* because it leaves the abdominal cavity external to the deep epigastric artery.

An inguinal hernia which forces its way into the inguinal canal at some point internal to the deep epigastric artery is termed a *direct or internal inguinal hernia,*—*direct,* because it passes straight forwards or directly into the inner end of the inguinal canal; *internal,* because it leaves the abdominal cavity internal to the deep epigastric artery.

Oblique or External Inguinal Hernia.—An oblique or external inguinal hernia may be either *congenital* or *acquired.* In the former case the infant is born with an unobliterated processus vaginalis peritonei, and there is thus an open peritoneal tube of communication existing at the time of birth between the abdominal cavity and the scrotum. The intestine slips down inside this process, and a congenital oblique or external inguinal hernia results.

Such a form of hernia leaves the abdomen at the internal or deep abdominal ring in the external inguinal fossa and immediately external to the deep epigastric artery. It then traverses the inguinal canal, and, emerging therefrom at the external or superficial abdominal ring, passes down into the scrotum.

Coverings of an Oblique or External Inguinal Hernia.

—By the coverings of a hernia are simply meant the various strata which the surgeon would require to cut through in order to reach the sac. It must not be imagined that the hernia, in its descent from the abdomen to the scrotum, actually pushes before it the various abdominal muscles. These have already been protruded into the scrotum by the various changes involved in the process of the descent of the testicle.

In a congenital oblique or external inguinal hernia the gut simply passes down inside the open peritoneal processus vaginalis. Its coverings are therefore precisely the same as those of the testicle and cord. In studying these various coverings it must be ever remembered that they are all derived from the various strata of the abdominal wall, and that the component strata receive somewhat slightly different names according as to whether the coverings of the cord or the coverings of the hernia are being spoken of.

The appended table shows side by side the coverings of the cord and of an oblique or external inguinal hernia, with the abdominal stratum from which each covering is derived, and the term applied to it.

Abdominal Wall.	Coverings of Cord.	Coverings of Oblique Hernia.
1. Peritoneum.	1. Tunica vaginalis.	1. The sac.
2. Extra-peritoneal fat.	2. Extra-peritoneal fat.	2. Extra-peritoneal fat.
3. Fascia transversalis.	3. Internal spermatic fascia.	3. Internal spermatic fascia.
4. Transversalis muscle.	4. Nothing.	4. Nothing.
5. Internal oblique muscle.	5. Cremasteric fascia.	5. Cremasteric fascia.
6. External oblique muscle.	6. External spermatic fascia.	6. External spermatic fascia.
7. Integuments.	7. Integuments.	7. Integuments.

An *acquired* oblique or external inguinal hernia is one that occurs at a period of life subsequent to birth, and after the processus vaginalis peritonei has become obliterated. Its course and coverings are precisely the same as in the congenital form. The only differences are that the hernia will itself protrude the parietal peritoneum of the abdomen in front of it as it descends, and that it will re-open the inguinal canal.

There is another variety of oblique or external inguinal hernia, which is usually termed *infantile hernia.* This variety depends on the fact that obliteration of the processus vaginalis peritonei has commenced at the time of birth in the region of the internal abdominal ring, but has not been completed.

Direct or Internal Inguinal Hernia.—A direct or internal inguinal hernia leaves the abdominal cavity internal to the deep epigastric artery, through either the middle or internal inguinal fossæ, but more frequently through the latter. It pushes the abdominal strata before it, and so forces its way into the inner end of the inguinal canal, from whence it emerges at the external abdominal ring as a hard, tense, globular swelling.

It is important to notice that a direct inguinal hernia, unlike a congenital oblique inguinal hernia, actually does push before it the various abdominal strata found in this region. These strata constitute the coverings of the hernia.

In the case of a direct hernia which leaves the abdominal cavity through the *internal inguinal fossa,* the coverings are as follows:—

1. The parietal peritoneum which constitutes the sac of the hernia.
2. The extra-peritoneal fat.
3. The fascia transversalis.
4. The conjoined tendon, formed behind the inner end of the inguinal canal by the fused aponeuroses of the internal oblique and transversalis abdominis muscles.
5. The inconstant triangular fascia.
6. The external spermatic fascia.
7. The integuments.

A direct or internal inguinal hernia is never so large as an oblique or external inguinal hernia, because the former has actually to push before it the abdominal strata, including the powerful conjoined tendon; whereas the latter simply passes through a previously formed canal.

A direct inguinal hernia most usually bulges through the external abdominal ring in the form of a tense, hard, globular swelling to which the term *Bubonocele* is sometimes applied.

A *direct inguinal hernia* which leaves the abdomen through the *middle inguinal fossa* will not push the conjoined tendon before it, but will enter the inguinal canal external to that tendon, and will then pass obliquely through the inner end of the inguinal canal, in front of the conjoined tendon, and will finally emerge at the external abdominal ring. Such a form of hernia is rare. A direct inguinal hernia usually leaves the abdominal cavity at the internal inguinal fossa, as previously stated.

III. THE ABDOMINAL CAVITY

Shape.—The abdominal cavity is ovoid in shape, with its longest diameter situated vertically.

Extent.—The abdominal cavity extends from the diaphragm above to the level of the pelvic inlet or brim below; it is thus obvious that the abdominal cavity lies altogether above the pelvic brim, and the abdominal cavity must not be confused with the pelvic cavity. In discussing the boundaries, it is, however, a matter of convenience to discuss to a certain extent the two cavities—abdominal and pelvic—together.

Boundaries of the Combined Abdominal and Pelvic Cavities.—The combined abdominal and pelvic cavities are bounded—*above*, by the dome-shaped diaphragm, concave downwards; *below*, by the dome-shaped pelvic floor, concave upwards, and formed by the levatores ani and coccygei muscles. Both the upper and lower boundaries are pierced by the various structures passing to or from the general abdominal and pelvic cavities.

Laterally, the abdominal cavity is bounded from above downwards by the ribs, the abdominal muscles, and by the expanded ilia; whilst the pelvic cavity has very complete osseous lateral boundaries, which are fully considered with the pelvis. (*See* page 148.)

Anteriorly, the abdominal cavity is bounded by the abdominal muscles only, with no osseous structures whatso-

ever. This is due to the fact that the costal cartilages of the ribs, which bound the abdomen laterally, ascend very obliquely in front to the sternum, and so leave the anterior wall of the abdomen devoid of an osseous protection.

Posteriorly, the abdominal cavity is bounded by the vertebral column, and the numerous thick muscles of the back.

The abdominal cavity is therefore notably deficient in osseous boundaries, the greater portion of its cavity being protected only by movable muscular walls. To compensate for this, all the more important viscera are situated very high up within the abdominal cavity—under shelter of the lower ribs and their costal cartilages; such viscera are, the liver, stomach, pancreas, spleen, kidneys, and duodenum. That portion of the abdominal cavity which is bounded by muscles only is occupied principally by the large and small intestine; whilst, lastly, the viscera of the abdomen, being so slightly protected by osseous structures, are easily compressed by muscular contraction, and are peculiarly liable to injury from all outside sources.

Subdivision of the Abdominal Cavity.—The contents of the abdomen are so numerous and important that it is absolutely essential to subdivide the abdomen into smaller regions. This may be done in many ways, two of which, those of Cunningham and Addison, are here given.

Cunningham's Method. — The abdominal cavity is divided, by Cunningham, into three zones, by means of two horizontal lines or planes. Each one of these three zones is further subdivided into three smaller areas by means of two vertical lines, making a total of nine abdominal regions.

The division of the abdomen into three zones is made by two horizontal lines or planes, termed infracostal or subcostal, and bi-iliac or intertubercular, respectively.

The *infracostal or subcostal plane* is drawn through the most dependent parts of the tenth costal arches; this plane usually cuts some part of the third lumbar vertebra.

The *bi-iliac or intertubercular plane* is drawn through the tubercle on the crest of the ilium, that is, through the most prominent part of the iliac crest, as seen from the front.

This plane usually cuts the middle of the anterior surface of the fifth lumbar vertebra.

The distance between the subcostal and bi-iliac planes averages about three inches, but varies, in different individuals, from one and a half to four inches.

Under ordinary conditions the umbilicus is situated midway between the two lines; that is, at a point some one and a half inches above the bi-iliac plane.

The *three zones* so mapped out are termed, from above downwards, the costal zone, the umbilical zone, and the hypogastric zone. The student will do well to remember that almost all the important abdominal viscera are situated in the costal zone.

Each one of these three zones is further subdivided into three smaller areas by means of two vertical lines drawn through the middle of Poupart's ligament, and hence termed the *right and left mid-Poupart planes.* The nine regions mapped out are named as follows:—

The Costal Zone.
1. The right hypochondriac region.
2. The epigastric region.
3. The left hypochondriac region.

The Umbilical Zone.
4. The right lumbar region.
5. The umbilical region.
6. The left lumbar region.

The Hypogastric Zone.
7. The right iliac region.
8. The hypogastric region.
9. The left iliac region.

Addison's Method.—As pointed out by Addison, there are several objections to Cunningham's method of delimiting the abdominal regions. The distance between the transverse lines, for example, is too variable to permit of any great degree of accuracy, hence Addison's method seems a preferable one.

By Addison's method the abdomen is first "divided *vertically* by three lines—a median line and two lateral lines."

The median line is drawn from the supra-sternal notch to the symphysis pubis.

The lateral lines are drawn vertically upwards, one on each side, through a point midway between the anterior superior iliac spine and the median line.

The vertical lines having been thus located, the transverse lines are found by a process of bisection, the body being divided *transversely* by lines drawn at points a quarter, a half, and three-quarters of the way along the median vertical line drawn from the supra-sternal notch to the symphysis pubis. These lines are termed from above downwards:—

The trans-thoracic plane.

The trans-pyloric plane, or the upper abdominal plane.

The trans-tubercular plane, or the lower abdominal plane.

(*a*) *The trans-thoracic plane* is a purely thoracic plane, and is of no significance in connection with the subdivision of the abdomen.

(*b*) *The upper abdominal plane* passes transversely through a point exactly midway between the supra-sternal notch and the symphysis pubis. As this plane has been found to pass almost invariably through the pylorus, it is well named the *trans-pyloric plane.*

(*c*) *The lower abdominal plane* corresponds almost exactly to the intertubercular plane of Cunningham, and may therefore be termed the *trans-tubercular plane.*

Addison's method resembles Cunningham's, inasmuch as it retains the subdivision of the abdomen into three zones—costal, umbilical, and hypogastric, but differs from it in the methods by which this is achieved, and in the further fact that the three zones are subdivided into four regions by means of the vertical lines, instead of into three as in Cunningham's method. Addison's method subdivides the three abdominal zones into twelve regions, as follows:—

The Costal Zone.

1. The right hypochondriac region.
2. The right epigastric region.

3. The left epigastric region.
4. The left hypochondriac region.

The Umbilical Zone.

5. The right lumbar region.
6. The right umbilical region.
7. The left umbilical region.
8. The left lumbar region.

The Hypogastric Zone.

9. The right iliac region.
10. The right hypogastric region.
11. The left hypogastric region.
12. The left iliac region.

In the present work the position of the abdominal viscera is given according to Cunningham's method, for the simple reason that there are not yet sufficient recorded data to locate the position of the viscera by the otherwise preferable system of Addison.

The Visceral Contents of the Abdominal Cavity.—The abdominal viscera comprise the different portions of the alimentary canal, the accessory glands to the alimentary canal, the ductless glands, and the urinary organs.

The *alimentary canal* comprises the following parts in order from the diaphragm onwards:—

- The termination of the œsophagus.
- The stomach.
- The small intestine.
  - The duodenum, or fixed intestine.
  - The jejuno-ileum, or floating intestine.
- The large intestine.
  - The cæcum.
  - The vermiform appendix.
  - The ascending colon and hepatic flexure.
  - The transverse colon and splenic flexure.
  - The descending colon.
  - The sigmoid flexure.
  - The rectum (situated in the pelvis).

Associated with some of the constituent parts of the alimentary canal are the various peritoneal folds, the most prominent of which is the gastro-colic omentum, which is

attached to the stomach and transverse colon, and which may, or may not, hang downwards in such a way as to conceal almost all the small intestine and some of the large intestine.

The *accessory glands to the alimentary canal* are the liver and the pancreas. The liver crosses the upper part of the abdominal cavity; the gall bladder is on the under surface of the liver, in the vicinity of the ninth right costal cartilage, whilst the pancreas lies behind the stomach, which altogether hides it from view.

The *ductless glands of the abdomen* are the spleen and the supra-renal capsules. The spleen is on the left side, altogether concealed by the ribs, and in contact with the stomach. It occupies the left hypochondrium and part of the epigastrium, and may be seen by drawing the stomach over to the right.

The supra-renal capsules surmount the upper ends of the kidneys, and as they as well as the kidneys lie on the posterior abdominal wall altogether behind the peritoneum, they are not at present visible.

The *urinary organs* comprise the two kidneys, and the ureters which, as just stated, cannot be seen till the other viscera and the peritoneum be removed.

Viscera in contact with the Anterior Abdominal Wall.—It is extremely important for the student to have some adequate conception of the various viscera in contact with the anterior abdominal wall. At the same time it is absolutely impossible to dogmatise on this subject, as the size, shape, position, and relations of all the abdominal viscera vary considerably, and in the case of the hollow viscera much depends on their degree of distension. Under ordinary circumstances the viscera in contact with the anterior abdominal wall are as follows, though numerous exceptions and variations must be expected in different cases:—

The Liver.—A small part of the anterior surface of the liver is in contact with that portion of the anterior abdominal wall which is bounded as follows:—Below, by a line drawn from the ninth right costal cartilage to the eighth left. This indicates the anterior and lower border of the liver. On either side, by the costal arches; above, by the ensiform cartilage.

The remaining portions of the anterior surface of the liver are concealed by the ribs and costal cartilages of the two sides.

The Gall Bladder.—The fundus of the gall bladder projects from below the inferior surface of the liver in such a way that, in 50 per cent. of cases, it is in contact with the anterior abdominal wall, in the vicinity of the ninth right costal cartilage, either in or immediately external to the right lateral line.

The Stomach.—When *distended*, the anterior surface of the stomach is in contact with the anterior abdominal wall, just below the liver. The pylorus is in the trans-pyloric plane of Addison, and in close contact with the neck of the gall bladder, altogether to the right of the middle line of the body.

When the stomach is *empty* it may recede upwards behind the liver in such a way that it is no longer in contact with the anterior abdominal wall. In such a case the transverse colon will then cross the anterior abdominal wall immediately below the liver, and no part of the stomach will be visible from the front. The possibility of this state of affairs must always be remembered in gastric operations upon patients who have been specially prepared for an anæsthetic. When the stomach is *empty* the pylorus lies in the middle line of the body four inches below the xiphi-sternal articulation.

The Transverse Colon.—The transverse colon usually crosses the anterior abdominal wall transversely in such a way that its intermediate portion is in contact with that wall immediately below the stomach, and about midway between the ensiform process and the umbilicus. Very great variations, however, are to be met with in connection with the transverse colon. If the stomach be empty the transverse colon may, as stated, be in contact with the liver; and quite apart from the state of the stomach, it is by no means unusual to find the transverse colon in many other positions than the one stated.

The right and left extremities of the transverse colon are deeply situated, and are not in contact with the anterior abdominal wall.

The Cæcum.—The cæcum is usually in contact with the anterior abdominal wall on the right side, just internal to the anterior superior iliac spine, and immediately above the outer half of Poupart's ligament. If the bladder is distended it is not unusual to find the cæcum tilted upwards in such a way that it comes into contact with the liver and gall bladder.

The Vermiform Appendix.—The vermiform appendix is only very occasionally in contact with the anterior abdominal wall, and that under conditions which are so irregular as to preclude any definite statements. It has been seen in contact with the anterior abdominal wall immediately external to the cæcum, and again, in the inguinal region.

The Sigmoid Flexure.—The sigmoid flexure is usually in contact with the anterior abdominal wall on the left side immediately to the inner side of the anterior superior iliac spine, and just above the outer half of Poupart's ligament. It has a somewhat analogous position on the left side to that of the cæcum on the right. It is by no means unusual, however, to find the sigmoid flexure much nearer the middle line, its so-called normal position being then occupied by small intestine, transverse colon, or great omentum.

The Bladder.—The bladder is only in contact with the anterior abdominal wall when it is fully distended. In that case it rises out of the pelvis, and is in contact with a varying portion of the abdominal wall immediately above the symphysis pubis. In extreme cases the bladder may rise as high as the umbilicus.

The Small Intestine.—That part of the small intestine known as the jejuno-ileum is in contact, either wholly or partly, with those parts of the anterior abdominal wall not already specified; or else it is partly in contact with the anterior abdominal wall, and partly separated therefrom by the great omentum.

The relations of the viscera to the anterior abdominal wall are thus extremely variable. The following summary of structures in contact with the anterior abdominal wall, in order from above downwards, in each one of Addison's three vertical lines, must therefore be regarded as merely an approximation to the truth. They are the averages resulting from a series of original observations by the author.

Right Lateral Line.	Median Line.	Left Lateral Line.
Liver.	Liver.	Stomach.
Gall Bladder.	Stomach.	Transverse Colon.
Transverse Colon, 50 p. c.	Transverse Colon.	Great Omentum.
Small Intestine.	Great Omentum.	Small Intestine.
Cæcum.	Small Intestine.	Sigmoid Flexure, 50 p. c.
	Bladder.	

The Peritoneum.—The peritoneum is the serous membrane which lines the cavity of the abdomen, and is reflected on to all the abdominal viscera; hence the peritoneum is described as consisting of a *parietal layer*, lining the walls of the abdominal cavity, and of a *visceral layer*, which is in contact with the abdominal viscera. The various abdominal viscera, it is most important to remember, lie altogether outside the peritoneal cavity, which cavity therefore contains nothing beyond a little peritoneal fluid. The various peritoneal relations of the abdominal viscera are, then, merely more or less complicated forms of invaginations of peritoneum.

1. The *simplest form* of this visceral invagination of the peritoneum is that represented by the kidneys. These viscera lie altogether behind the peritoneum, and therefore outside the peritoneal cavity. They merely indent the peritoneum as it were, from behind, consequently the anterior surfaces only of these viscera are in contact with peritoneum.

2. A *slightly more complicated form* of this invagination of the peritoneum by viscera is that represented by the spleen. Here the spleen has so far invaginated the peritoneal cavity as to be entirely surrounded by peritoneum, the viscus itself still remaining outside the peritoneal cavity.

3. The *most complicated stage* of this invagination is that produced by the stomach, which not only invaginates the peritoneum, but subsequently rotates in such a way as to produce a posterior peritoneal cul-de-sac, termed the *lesser peritoneal sac.* The aperture of communication between the posteriorly situated lesser sac and the anteriorly situated

greater sac constitutes the *foramen of Winslow.* The lesser peritoneal sac subsequently invaginates the greater peritoneal sac from behind forwards, and so produces the four layers of the *gastro-colic omentum.*

The peritoneum is the largest and most complicated serous membrane in the body; in the male it is an absolutely closed sac, but in the female it communicates with the Fallopian tubes, and hence with the vagina.

The detailed study of the peritoneum and its numerous ramifications is best accomplished by a series of sections, as follows:—

A transverse section through the umbilicus.
A transverse section through the foramen of Winslow.
A vertical section through the sagittal plane.

A Transverse Section through the Umbilicus.—In such a section, commencing at the umbilicus, the peritoneum will be seen to line the anterior abdominal wall, to pass round that wall to the ascending colon, thence in front of that structure along the posterior abdominal wall, from which it is reflected off by means of the superior mesenteric vessels to the small intestine which it entirely surrounds, and thence back to the posterior abdominal wall. The two layers of peritoneum which have thus been reflected off the posterior abdominal wall round the small intestine constitute the *enteric mesentery.* Having regained the posterior abdominal wall, the peritoneum then passes in front of the descending colon back to the starting point.

A Transverse Section through the Foramen of Winslow.—The object of this section is to demonstrate the absolute continuity of the apparently detached greater and lesser peritoneal sacs, the point at which the continuity is established forming the *foramen of Winslow.* Such a section will cut the twelfth dorsal vertebra.

Commencing at the anterior abdominal wall and passing round to the right, the peritoneum will be noticed to line the abdominal wall and to pass in front of the inferior vena cava. At this point the peritoneum is forming one of the posterior boundaries of the foramen of Winslow.

The peritoneum then passes on to the left as the most posterior layer of the lesser sac, and, crossing in front of the left kidney as the right layer of the *lieno-renal ligament*, reaches the spleen, which constitutes the farthest extension of the lesser sac to the left. At the spleen the peritoneum of the lesser sac passes forwards to the stomach as the right layer of the *gastro-splenic omentum.* The peritoneum, having reached the stomach at the greater curvature, then passes behind the posterior surface of the stomach to the lesser curvature, from whence the peritoneum extends to the right lateral free margin of the *gastro-hepatic omentum*, as the posterior layer of that omentum. At the right lateral free margin of the gastro-hepatic omentum the peritoneum lies in front of the foramen of Winslow, and contains between its two layers the common bile duct, the hepatic artery, and the portal vein. From this point the peritoneum passes again to the left, as the most anterior layer of the *gastro-hepatic omentum*, and so reaches the lesser curvature of the stomach; then passing in front of the anterior surface of that viscus it reaches the greater curvature, from whence it is reflected on to the spleen as the left layer of the *gastro-splenic omentum.* The peritoneum then surrounds the spleen, from which viscus it is reflected on to the left kidney as the left layer of the *lieno-renal ligament.* From the kidney the peritoneum passes on to the posterior wall of the abdomen, and so back again to the starting point. The peritoneum is reflected off the anterior abdominal wall by the obliterated umbilical vein to form the *falciform ligament* of the liver.

A Vertical Sagittal Section.—Although the peritoneum is a single and absolutely continuous structure, a vertical sagittal section gives the appearance of two peritoneal sacs, one in front of and partially invaginated by the other. This appearance is, of course, due to the invagination from behind forwards of the greater sac by the lesser sac.

If the peritoneum forming the *greater peritoneal sac* be first traced from the umbilicus, it will be noticed to pass upwards on the anterior abdominal wall and to line the under surface of the diaphragm, from whence it is reflected on to the liver as the upper layer of the *coronary ligament* of that structure. Having so reached the liver, the peritoneum

successively passes round its superior, anterior, and inferior surfaces, until the transverse fissure of the liver is reached on the inferior surface of that viscus, from whence the peritoneum passes downwards as the anterior layer of the *gastro-hepatic omentum* to the lesser curvature of the stomach. Passing in front of the stomach, it reaches the greater curvature of that organ, and then passes downwards to the most dependent point of the *gastro-colic omentum*, as the first or most anterior layer of that omentum. From this point the peritoneum passes upwards to the transverse colon as the fourth or most posterior layer of the *gastro-colic omentum*. Passing round the posterior surface of the transverse colon, the peritoneum next passes backwards to the posterior abdominal wall as the most posterior layer of the *transverse meso-colon*; this layer of peritoneum reaches the posterior abdominal wall at the level of the anterior border of the pancreas. It then passes backwards along the inferior surface of the body of the pancreas and turns downwards until it is again reflected off by the superior mesenteric vessels to form the *enteric mesentery*, and so surrounds the jejuno-ileum, having done which, the peritoneum regains the posterior abdominal wall as the deep layer of the *enteric mesentery*, and then passes back to the starting point through the pelvis.

The peritoneum forming the *lesser peritoneal sac* may be traced from the transverse fissure of the liver. Commencing at this point, the peritoneum of the lesser sac first passes downwards to the lesser curvature of the stomach as the posterior layer of the *gastro-hepatic omentum*; it then passes behind the posterior surface of the stomach to the greater curvature of that organ, from whence it descends to the most dependent point of the *gastro-colic omentum* as the second layer of that omentum; it next ascends to the transverse colon as the third layer of the *gastro-colic omentum*. The peritoneum then passes in front of the transverse colon and then back to the posterior abdominal wall as the anterior layer of the *transverse meso-colon*, and reaches the posterior abdominal wall at the level of the anterior border of the pancreas.

From this point the peritoneum of the lesser sac ascends along the posterior abdominal wall, passing successively upwards in front of the anterior surface of the body of the pancreas, the cœliac axis and its main divisions, the upper part of the left kidney, and the diaphragm. At this point the peritoneum of the lesser sac is reflected on to the liver, passing downwards in contact with the Spigelian lobule on the posterior surface of the liver, and then turns forwards on the inferior surface of the liver to the starting point at the transverse fissure.

Boundaries of the Lesser Sac.—The lesser peritoneal sac is bounded as follows:—

Above.—By the reflection of the peritoneum from the diaphragm to the Spigelian lobule of the liver.

Below.—By the most dependent point of the gastro-colic omentum.

On the right.—By the foramen of Winslow.

On the left.—By the gastro-splenic omentum.

In front, and from above downwards, by—
- The Spigelian lobule of the liver.
- The gastro-hepatic omentum.
- The stomach.
- The anterior two layers of the gastro-colic omentum.

Behind, from below upwards—
- The posterior two layers of the gastro-colic omentum.
- The transverse colon.
- The transverse meso-colon
- By the layer of peritoneum which ascends in front of the posterior abdominal wall.

In the adult the cavity of the lesser peritoneal sac seldom extends so far downwards as described, because the four layers of the gastro-colic omentum usually fuse together in the lower part of their extent. In the fœtus, however, the cavity actually does extend downwards as far as the most dependent point of the gastro-colic omentum.

The Foramen of Winslow.—The aperture of communication between the greater and lesser peritoneal sacs is termed the *foramen of Winslow.* This important structure is bounded as follows:—

In front.—By the right lateral free margin of the gastro-hepatic omentum and its contained structures, which are the common bile duct, the hepatic artery, and the portal vein.

Behind.—By the inferior vena cava, this structure being separated from the foramen by peritoneum belonging to the lesser sac.

Above.—By the caudate lobule of the liver.

Below.—By the first part of the duodenum and the hepatic artery.

Subdivisions of the Peritoneum.—In consequence of the large size and complicated nature of the peritoneum it is subdivided into various parts.

These parts are termed respectively, omenta, mesenteries, and ligaments.

An *Omentum* is a double fold of peritoneum connecting the stomach to some other viscus. There are three omenta, as follows:—

The small or gastro-hepatic omentum.
The great or gastro-colic omentum.
The least or gastro-splenic omentum.

A *Mesentery* is a double fold of peritoneum connecting the intestinal canal to the posterior abdominal wall. There are several mesenteries, which may be either constant or inconstant, as follows:—

Constant—

The enteric mesentery.
The meso-appendix.
The transverse meso-colon.
The meso-sigmoid.
The meso-rectum.

Inconstant—

The ascending meso-colon.
The descending meso-colon.

A *Ligament* is a double fold of peritoneum which—

(*a*) Connects viscera which are not part of the intestinal canal to the walls of the abdomen or pelvis, as—

The ligaments of the liver.
The ligaments of the bladder.
The ligaments of the uterus.

(*b*) Or, secondly, a peritoneal ligament is a double fold of peritoneum which connects any viscus to the diaphragm—

The lieno-renal ligament.
The phrenico-colic ligament.
The gastro-phrenic ligament.

The Small or Gastro-Hepatic Omentum.—This is a double fold of peritoneum which connects the stomach to the liver.

Below, it is attached to the lesser curvature of the stomach and the pyloric end of the first part of the duodenum.

Above, it is attached to the transverse fissure of the liver, to the posterior part of the longitudinal fissure of the liver, and to the diaphragm. Its *right lateral margin* is free, and constitutes the anterior boundary of the foramen of Winslow. By its *left extremity* it is attached to the lesser curvature of the stomach.

Between the two layers of this omentum there are the hepatic artery, the common bile duct, the portal vein, the coronary artery and vein, the pyloric artery and vein, and the gastro-duodenal artery.

The Great or Gastro-Colic Omentum.—This, the largest of all the peritoneal folds, constitutes a species of apron, which hangs from the stomach and transverse colon.

It is composed of four layers of peritoneum; the two anterior layers are attached to the greater curvature of the stomach and to the pyloric end of the first part of the duodenum, while the two posterior layers are attached to the transverse colon. The first and fourth layers of this omentum belong to the peritoneum of the greater sac; the second and third are formed entirely by peritoneum belonging to the lesser sac. Along its gastric attachment run the right and left gastro-epiploic vessels.

In the adult the four layers of this omentum fuse

together, especially at the lower part, in such a way that it is impossible to demonstrate the four constituent strata of which the omentum is composed.

The Least or Gastro-Splenic Omentum.—This is a small double fold of peritoneum which connects the stomach to the spleen. It passes from the fundus of the stomach to the hilum of the spleen, and between its two layers the vasa brevia branches of the splenic artery reach the stomach.

The Enteric Mesentery.—This is a large double fold of peritoneum which connects the jejuno-ileum to the posterior abdominal wall. The point of attachment of the enteric mesentery to the posterior abdominal wall is termed its root.

The *root of the enteric mesentery* is about six inches long; it is attached to the posterior abdominal wall along an oblique line, which extends from the left side of the body of the second lumbar vertebra downwards to the right into the right iliac fossa. In this course the root of the enteric mesentery successively crosses the third part of the duodenum, the aorta, the inferior vena cava, and the right psoas muscle.

The *intestinal border* of the enteric mesentery is about twenty-one feet long, and corresponds to the jejuno-ileum. Contained between the two layers of the enteric mesentery there are the jejuno-ileum, the superior mesenteric vessels and nerves, lymphatics, glands, lacteals, and fat.

Measured from its parietal to its visceral attachment, the enteric mesentery is longer in the middle than at either end.

The Meso-Appendix.—The meso-appendix is a double fold of peritoneum which connects the vermiform appendix to the posterior or left layer of the enteric mesentery. The term "mesentery," as applied to this fold, is therefore a misnomer.

Although the meso-appendix varies considerably it usually presents for examination four borders, superior or mesenteric, right or cæcal, left or free, and inferior or appendicular.

The *superior or mesenteric* border is attached to the posterior or left layer of the enteric mesentery along a straight line which is situated just above the termination of the ileum.

The *right or cæcal* border is attached to the left lateral wall of the cæcum.

The *left* border is free. It passes from the enteric mesentery above, to the vermiform appendix below.

The *inferior or appendicular* border surrounds and is attached to the vermiform appendix.

Between the two layers of the meso-appendix are found the vermiform appendix, branches from the ileo-colic artery, the corresponding veins, nerves, lymphatics, and fat.

The Transverse Meso-Colon.—This is attached to the posterior abdominal wall at the level of the anterior border of the pancreas, from whence it passes downwards to the transverse colon. It is longest in the middle line of the body, and contains between its two layers the transverse colon and the middle colic vessels.

That part of the transverse meso-colon which lies to the left of the second part of the duodenum is formed by both the great and the small peritoneal sacs, whereas that part which crosses in front of the second part of the duodenum is formed by peritoneum of the greater sac only.

The Meso-Sigmoid.—This is a double fold of peritoneum which connects the sigmoid flexure to the left iliac fossa. The root of the mesentery is oblique, and runs from the highest point of the iliac crest downwards and to the right, to the left sacro-iliac articulation. It contains between its two layers the sigmoid flexure and the sigmoid vessels.

The Meso-Rectum.—(*See* page 166.)

The Inconstant Mesenteries.—These are too variable to require description.

The Ligaments of the Liver, Bladder, and Uterus.—These are described with their respective viscera.

The Lieno-Renal Ligament.—This is a double fold of peritoneum which passes from the spleen around the left kidney to the diaphragm. Between its two layers the splenic artery reaches the spleen. This ligament is formed of peritoneum belonging to both the greater and lesser sacs.

The Phrenico-Colic Ligament.—This is a small, free, crescentic fold of peritoneum which connects the splenic

flexure of the colon to the diaphragm opposite the tenth or eleventh ribs. The spleen rests upon this ligament.

The Gastro-Phrenic Ligament.—This is a small fold which connects the fundus of the stomach to the diaphragm. It is placed close to the œsophagus, immediately to its left side.

The Alimentary Canal.—The alimentary canal, within the abdomen and pelvis, is composed of the following parts:—

- The termination of the œsophagus.
- The stomach.
- The small intestine.
  - The duodenum, or fixed intestine.
  - The jejuno-ileum, or floating intestine.
- The large intestine.
  - The cæcum.
  - The vermiform appendix.
  - The ascending colon and hepatic flexure.
  - The transverse colon and splenic flexure.
  - The descending colon.
  - The sigmoid flexure.
  - The rectum (situated in the pelvis).

The Termination of the Œsophagus.—The abdominal portion of the œsophagus is very short, and extends from the œsophageal aperture in the diaphragm to the cardia. It passes obliquely downwards and to the left, and is lodged in a groove on the posterior surface of the left lobe of the liver.

The Stomach.—The stomach is the dilated portion of the alimentary canal which is situated between the termination of the œsophagus and the commencement of the small intestine. Its size, shape, position, direction, and relations vary considerably under normal physiological conditions.

Position.—When *empty*, the stomach lies in the left hypochondrium and the left half of the epigastrium, the pylorus being situated in the middle line of the body four inches below the xiphi-sternal articulation.

Direction—The greater part of the empty stomach is vertical in direction, at least three-fourths of the viscus being situated in the long axis of the body. The pyloric fourth is almost horizontal. As the stomach becomes distended it gradually becomes more oblique, and the pylorus moves over to the right, and then backwards.

Description.—The *moderately distended stomach* may be described as a pyriform organ presenting for examination *two extremities,* a fundus and an antrum pylori; *two orifices,* a cardia and a pylorus; *two curvatures,* a lesser and a greater curvature; *two surfaces,* anterior and posterior.

The *fundus* is the rounded upper end of the stomach to the left of the cardia. It projects upwards, and is in contact with the left cupola of the diaphragm, which separates it from the left lung and the heart. It gives attachment to the gastro-phrenic ligament.

The *antrum pylori* is the slight dilatation in front of and to the left of the pylorus.

The *cardia* is the œsophageal opening into the stomach. It is the most fixed part of the stomach, and is situated opposite the body of the tenth dorsal vertebra, in front of and to the left side of the aorta, and behind a notch in the posterior surface of the left lobe of the liver. The cardia lies four or five inches behind a point on the seventh left costal cartilage, one inch from its junction with the sternum.

The *pylorus* is the duodenal orifice of the stomach. When the stomach is empty it lies in the middle line of the body, four inches below the xiphi-sternal articulation, and opposite the body of the first lumbar vertebra.

The pylorus is the most movable part of the stomach, and as the stomach distends the pylorus moves to the right of the middle line of the body and then backwards, until it comes into close relationship with the neck of the gall bladder.

The position of the pylorus is marked by a slight muscular thickening at the junction of the stomach and duodenum.

The *lesser curvature* is concave. It gives attachment to the gastro-hepatic omentum; and the coronary and pyloric vessels course along it.

The *greater curvature* is convex, and is about three times as long as the lesser. It is usually in contact with the

transverse colon. It gives attachment to the gastro-splenic and gastro-colic omenta. The vasa brevia branches from the splenic artery, and the right and left gastro-epiploic vessels course along it.

The *anterior surface* of the stomach is, when that viscus is moderately distended, in contact from above downwards with the liver, the diaphragm, and the anterior abdominal wall. For surgical purposes it is important to remember that, when empty, the stomach may altogether recede behind the left lobe of the liver.

The *posterior surface* of the stomach has most important relations. These are as follows:—

- The diaphragm. There is a small non-peritoneal surface above and to the left of the cardia, where the posterior surface is in direct contact with the diaphragm.
- The left suprarenal capsule and the gastric surface of the spleen.
- The upper end of the anterior surface of the left kidney.
- The splenic artery.
- The anterior surface of the body of the pancreas.
- The transverse meso-colon, which separates the stomach from the duodeno-jejunal flexure, and from some coils of the small intestine.

Peritoneal Relations.—The stomach is entirely invested by peritoneum, with the exceptions of the very small areas along the two curvatures, and the small bare area to the left of the cardia, where the stomach comes to lie in direct contact with the diaphragm.

Attached to the *greater curvature* of the stomach there are the following peritoneal folds:—

- The gastro-phrenic ligament.
- The gastro-splenic omentum.
- The gastro-colic omentum.

Attached to the *lesser curvature* of the stomach there is the gastro-hepatic omentum.

Arterial Supply.—The stomach is supplied by branches which are derived from the three divisions of the cœliac axis—coronary, splenic, and hepatic.

Along the *lesser curvature* of the stomach there are the following arteries:—

The coronary artery from the cœliac axis.

The pyloric artery, a branch of the hepatic division of the cœliac axis.

Along the *greater curvature* of the stomach there are:—

The vasa brevia branches from the splenic division of the cœliac axis.

The left gastro-epiploic artery from the splenic division of the cœliac axis.

The right gastro-epiploic artery, one of the terminal branches of the gastro-duodenal artery, a branch of the hepatic division of the cœliac axis.

Venous Return.—All the venous blood from the stomach passes either directly or indirectly into the portal system.

The *coronary* and *pyloric* veins terminate directly in the portal vein.

The *vasa brevia* veins and the *left gastro-epiploic* vein terminate in the splenic vein, which unites with the superior mesenteric vein to form the portal vein.

The *right gastro-epiploic* vein terminates in the superior mesenteric vein.

The Internal Surface of the Stomach.—The mucous membrane of the stomach is so loosely connected to the muscular coat by the intervening submucosa that it permits a considerable amount of mobility to the mucous membrane itself. Partly on account of this, and partly on account of the inelasticity of the gastric mucous membrane, it is thrown, when the stomach is empty, into numerous convoluted ridges, termed *rugæ.* These rugæ are best marked along the greater curvature, have a longitudinal direction, and are obliterated by distension of the stomach.

The Cardiac Valve.—In the region of the cardia the mucous membrane often, but by no means constantly, forms a rudimentary crescentic cardiac valve. This, when present, usually projects down for a very short distance, into the interior of the stomach, from the left side of the œsophageal opening.

The Pyloric Valve.—In the region of the pylorus the

mucous membrane forms a very well-marked circular or oval fold, which is termed the *pyloric valve.* It contains, between its two layers, a thickening of the circular muscular coat of the stomach, which is termed the *sphincter pylori* muscle.

The Small Intestine.—The small intestine commences at the pylorus in the epigastrium, and terminates at the ileo-cæcal valve in the right iliac fossa.

Its length is about twenty-two feet, and its convolutions occupy the middle and lower parts of the abdomen, and very frequently descend into the pelvis.

It is somewhat arbitrarily divided into three parts—the duodenum, the jejunum, and the ileum. A better subdivision is, however, made as follows:—

The duodenum, or fixed portion of the small intestine.

The jejuno-ileum, or floating part of the small intestine.

The Duodenum.—The duodenum constitutes the first ten or twelve inches of the small intestine immediately succeeding to the stomach.

Characteristics.—Its chief characteristics are its fixed position, its close relation to the head of the pancreas, the absence of a mesentery, and its larger diameter as compared with the rest of the small intestine.

Position.—The duodenum occupies the epigastrium and the umbilical region. Its origin and termination are both situated in the epigastrium.

Description.—The duodenum commences at the pylorus, and terminates at the duodeno-jejunal flexure, opposite the upper border of the second lumbar vertebra, and on its left side. It is about ten or twelve inches long, and may be divided into three or four parts. These four parts together form a well-marked horseshoe-shaped curve, the extremities of this curve lying in a coronal plane, and the intermediate part in a more nearly sagittal plane (Birmingham).

The First Part of the Duodenum.—This is two inches long, and, when the stomach is empty, passes to the right and then backwards, to end opposite the first lumbar vertebra.

Its anterior surface is entirely covered by peritoneum, but the posterior surface is only covered by peritoneum at its inner or pyloric end.

The relations, as well as the position of the first part of the duodenum, depend upon the degree of distension of the stomach. When that viscus is empty and the pylorus is in the middle line of the body, the first part of the duodenum, which is situated entirely in the epigastrium, passes to the right and then almost directly backwards. When the stomach is distended and the pylorus has passed to the right and then backwards, the whole of the first part of the duodenum occupies a sagittal plane; that is to say, it extends from the pylorus directly backwards to its termination. The first part of the duodenum is therefore its most movable part.

When the stomach is empty the relations of the first part of the duodenum are as follows:—

Above—
- The quadrate lobule of the liver.
- The foramen of Winslow.

In Front—
- The gall-bladder.

Behind—
- The portal vein.
- The gastro-duodenal artery.
- The common bile duct.

Behind and to the Inner Side.—The neck of the pancreas.

The Second Part of the Duodenum.—This commences just below the neck of the gall-bladder opposite the first lumbar vertebra, and extends vertically downwards for three inches, to end at the lower border of the third lumbar vertebra.

In front it is entirely covered by peritoneum, with the exception of the small interval which is left between the two layers of the transverse meso-colon, which crosses this part of the duodenum transversely.

The posterior surface has no peritoneal covering whatsoever, but is in direct contact with the hilum of the right kidney and its vessels, and with the inferior vena cava.

The relations are as follows:—

To the Right.—The hepatic flexure of the colon.

To the Left.—The head of the pancreas.

In Front—
  - The liver.
  - The transverse meso-colon.
  - The transverse colon.

Behind—
  - The hilum of the right kidney.
  - The renal vessels.
  - The inferior vena cava.

The common bile duct runs vertically downwards behind the left border of this part of the duodenum, and, after being joined by the duct of the pancreas, opens into its inner and back part a little below its middle.

The Third Part of the Duodenum.—This commences opposite the third lumbar vertebra, and runs transversely to the left for three inches; just before its termination on the left side of the aorta it ascends slightly, to end in the fourth part.

Its anterior surface is entirely covered by peritoneum, except in the middle line where the superior mesenteric vessels cross this part of the duodenum, and so raise the peritoneum from off its anterior surface.

Its relations are as follows:—

In Front—
  - Peritoneum.
  - The superior mesenteric vessels.

Behind—
  - The inferior vena cava.
  - The aorta.

Above.—The head of the pancreas.

The Fourth Part of the Duodenum.—This passes upwards on the left side of the aorta, as high as the upper border of the second lumbar vertebra, where it terminates abruptly in the duodeno-jejunal flexure by becoming continuous with the jejuno-ileum.

Its anterior and left surfaces are alone covered by peritoneum, and its upper end—that is, the duodeno-jejunal flexure—is retained in position by the *suspensory muscle of the duodenum,* a strong fibrous band which descends from the left crus of the diaphragm to the flexure.

The relations of the fourth part of the duodenum are—

In Front.—The transverse meso-colon, which separates it from the stomach.

Behind—

The left renal vein.
The left psoas muscle.

The Duodenal Peritoneal Fossæ.—In connection with the fourth part of the duodenum especially, the peritoneum, which normally covers the anterior and left surfaces of this part of the viscus, is occasionally reflected off in such a way as to form certain well-marked duodenal peritoneal fossæ.

Five varieties of such fossæ are, according to Jonnesco, occasionally to be found. These are superior duodenal, inferior duodenal, retro-duodenal, para-duodenal, and duodeno-jejunal. Of these five the first two are alone of any importance, and are by far the most constant.

The *superior duodenal fossa* is formed by a small fold of peritoneum which passes from the front of the fourth part of the duodenum near its termination, backwards and to the left, to the posterior abdominal wall. The orifice of the fossa is directed downwards.

The *inferior duodenal fossa* is formed by a small fold of peritoneum which passes from the front of the fourth part of the duodenum near its origin, backwards and to the left, to the posterior abdominal wall. This fold possesses an upper, free, and somewhat crescentic margin. The orifice of the fossa itself is directed upwards.

One or both of these two fossæ are almost constantly present. Their importance, surgically, consists in the fact that a loop of intestine may be involved and possibly strangulated, within one or other of these fossæ.

Arterial Supply.—The arterial supply to the duodenum is derived indirectly from the cœliac axis, and directly from the superior mesenteric artery as follows:—

1. The superior pancreatico-duodenal artery supplies the first and second parts of the duodenum. This vessel is a branch of the gastro-duodenal artery, from the hepatic division of the cœliac axis.

2. The inferior pancreatico-duodenal artery, a branch of the superior mesenteric artery, supplies the third and fourth parts of the duodenum.

The Jejuno-Ileum.—Of the remaining twenty-one feet of small intestine, the jejunum forms the upper two-fifths and the ileum the lower three-fifths. The two together constitute the floating part of the small intestine, under the name jejuno-ileum.

Extent and Position.—The jejuno-ileum commences at the duodeno-jejunal flexure in the epigastrium on the left side of the upper border of the body of the second lumbar vertebra. After a course of twenty-one feet it terminates in the right iliac fossa in the ileo-cæcal junction.

The jejuno-ileum occupies the umbilical, hypogastric, lumbar, and iliac regions; that is to say, the middle and lower parts of the abdomen. Coils of ileum are almost invariably found in the pelvis, and it is not infrequent to find some coils of jejunum lying in the left hypochondrium.

Mobility.—The jejuno-ileum is freely movable, and is the most movable part of the intestinal canal. This mobility is due to the fact that the jejuno-ileum is suspended to the posterior abdominal wall by the loose and movable enteric mesentery.

The most fixed portion of the jejuno-ileum is the terminal portion of the ileum, which is most frequently seen ascending out of the pelvic cavity across the right psoas muscle to terminate in the large intestine at the ileo-cæcal junction.

Relations to Peritoneum.—The jejuno-ileum is entirely surrounded by and lies between the two layers of the enteric mesentery.

Arterial Supply.—The arterial supply to the jejuno-ileum is derived from the superior mesenteric artery by means of the vasa intestini tenuis arteries. These vessels form a remarkable series of arterial arcades before finally terminating in the coils of the jejuno-ileum. All these vessels lie between the two layers of the enteric mesentery.

The Internal Surface of the Small Intestine.—In connection with the mucous membrane on the internal surface of the small intestine, there are certain general macroscopic and microscopic features to which special attention should be directed. These are as follows:—

1. Valvulæ conniventes.
2. Villi.
3. Glands.
    - (*a*) Crypts of Lieberkühn.
    - (*b*) Brunner's glands.
    - (*c*) Solitary glands.
    - (*d*) Peyer's patches.

1. *The Valvulæ Conniventes.*—The mucous membrane of the small intestine is heaped up into numerous transverse folds or rugæ, which, unlike those found in the stomach, cannot be obliterated by distension. These permanent folds, which are found generally throughout the whole of the small intestine, are termed *valvulæ conniventes.*

The valvulæ conniventes are crescentic projections of the mucous membrane placed transversely to the long axis of the gut, and extending into its interior for about one-third of an inch. Each fold consists of a double fold of mucous membrane placed back to back and connected together by the submucosa without any intervening muscular tissue.

Three varieties of valvulæ conniventes are described:—(*a*) The majority extend round the gut for about one-half or two-thirds of its circumference. (*b*) A few form a complete circle round the gut. (*c*) The minority form a spiral round the gut, and generally extend once round it, but may in rare cases go round two or three times. The spiral forms occur singly or in groups of two or three, and their extremities are often bifurcated.

The valvulæ conniventes serve to increase the absorbent surface of the intestine, but are not uniformly distributed throughout the small intestine.

In the duodenum the valvulæ conniventes first make their appearance a short distance beyond the pylorus, and attain their greatest development in the lower half of the duodenum, that is, beyond the common duodenal orifice of the common bile duct and the pancreatic duct. They continue to

be well marked throughout the upper or jejunal portion of the jejuno-ileum, but beyond this become more and more feebly marked, until towards the middle or lower end of the ileum they finally disappear.

2. *The Villi.*—The villi are peculiar to the small intestine. They are very closely set over every part of the mucous membrane both upon and between its valvulæ conniventes, and give to the mucous membrane its peculiar velvety appearance.

The villi are largest and most numerous in the duodenum and jejunum. They are stated to be short and leaf-shaped in the duodenum, long and tongue-shaped in the jejunum, and still longer and more filiform in the ileum.

There are stated to be some four million villi within the small intestine.

3. *The Glands.*—(*a*) *Crypts of Lieberkühn.*—The crypts of Lieberkühn are found opening on the surface of the mucous membrane between the villi, throughout the whole of the small intestine. They are longest in the duodenum.

(*b*) *Brunner's Glands.*—These are racemose glands found in the duodenum only. They are situated in the submucosa, and are most numerous at the upper or pyloric end of the duodenum.

(*c*) *Solitary Glands.*—Solitary glands are masses of lymph tissue found scattered over the mucous membrane throughout the whole of the small intestine, but they are more numerous towards its lower end.

(*d*) *Peyer's Patches.*—Peyer's patches are groups or patches of lymphoid tissue of an oblong form, varying in size from half an inch to two or even four inches in length, by about half an inch in breadth. Their long axis corresponds to that of the intestine, and they are usually situated opposite the enteric attachment of the mesentery.

Peyer's patches are best marked, and are more closely aggregated together at the lower end of the ileum, and are either few in number or entirely absent in the jejunum. In all, there are about twenty to thirty of such patches present in the jejuno-ileum. They are best marked in the young subject, and tend to disappear with advancing age.

Summary.—The differences between the various portions of the small intestine may be summarised as follows:—

Duodenum.	Jejuno-Ileum.	
	(*a*) Jejunum.	(*b*) Ileum.
1. Absolute fixity.	1. Freely movable.	1. Freely movable.
2. Absence of mesentery.	2. Enteric mesentery.	2. Enteric mesentery.
3. Greatest diameter.	3. Diminishing diameter.	3. Smallest diameter.
4. Valvulæ conniventes best marked.	4. Valvulæ conniventes well marked.	4. Valvulæ conniventes disappear.
5. Villi large, numerous, leaf-shaped.	5. Villi large, not so numerous, long, tongue-shaped.	5. Villi few in number, but longer and more filiform.
6. Lieberkühn's glands longest.	6. Lieberkühn's glands shorter.	6. Lieberkühn's glands shorter.
7. Brunner's glands present.	7. Brunner's glands absent.	7. Brunner's glands absent.
8. Solitary glands doubtful.	8. Solitary glands present.	8. Solitary glands numerous.
9. Peyer's patches absent.	9. Peyer's patches few in number, generally circular.	9. Peyer's patches numerous, larger, more oblong.

Meckel's Diverticulum.—Meckel's diverticulum is a small blind pouch or diverticulum given off by the ileum in about 2 per cent. of cases. It is usually of the same calibre as the ileum, and about two or three inches long. It springs from the gut opposite the enteric attachment of the mesentery, usually about forty-three inches above the ileo-cæcal junction, though this is liable to variation.

Meckel's diverticulum represents an abnormally persisting intestinal end of the neck of the yolk sac.

The Large Intestine.—The large intestine is about five or six feet long, and constitutes one-fifth of the whole length of the intestinal canal.

Its diameter, which is considerably greater than that of the small intestine, gradually diminishes from its commencement to its termination.

The Cæcum.—The cæcum is that part of the large intestine which is situated below the ileo-cæcal valve. It is the widest part of the intestinal canal, its average dimensions being about two and a half inches in length by two and

three-quarters in breadth. The transverse diameter of the cæcum is always greater than its vertical diameter.

Relations.—The cæcum is subject to many variations in position, hence its relations are variable. Under ordinary conditions the cæcum occupies the right iliac fossa, being in contact with the anterior abdominal wall in front, and with the ilio-psoas muscle posteriorly. To its left side are coils of small intestine, and the terminal portion of the ileum passing upwards out of the pelvis.

Relations of the Cæcum to Peritoneum.—The cæcum is entirely surrounded by peritoneum. A meso-cæcum does not exist.

In about 5 per cent. of cases the peritoneum is reflected off the posterior abdominal wall on to the cæcum a little lower than usual; hence in this percentage of cases there is a very small part of the posterior surface of the cæcum near its upper limit which is in direct non-peritoneal contact with the posterior abdominal wall.

As the cæcum is entirely surrounded by peritoneum it is freely movable within the abdominal cavity. During distension of the bladder the cæcum is tilted forwards and upwards, and with a full bladder it is not unusual to find the cæcum in contact with the liver.

The Peri-Cæcal Peritoneal Folds and Fossæ.—In connection with the cæcum and appendix, the peritoneum usually forms certain distinct folds and fossæ, which, however, are by no means constantly present, with perhaps the exception of the meso-appendix. These folds and the resulting fossæ are as follows:—

Peritoneal Folds.	*The Resulting Fossæ.*
The ileo-colic fold	The ileo-colic fossa.
The ileo-cæcal fold	The ileo-cæcal fossa.
The meso-appendix	

The ileo-colic fold is a small process of peritoneum situated at the ileo-colic angle, which passes from the upper or right layer of the enteric mesentery in front of the terminal portion of the ileum, on to the large intestine just above, or sometimes even extending below, the anterior frænal furrow.

This fold is produced by a branch of the ileo-colic artery passing to the cæcum. It serves to prevent any interference with the vascular supply during the various alterations in distension and situation of the cæcum.

The ileo-colic fossa is the minute fossa produced by the fold of the same name.

The ileo-cæcal fold is a small fold situated in the angle between the ileum and the cæcum. It is attached to both these structures and also to the meso-appendix, some part of which usually lies behind the ileo-cæcal fold.

The meso-appendix. (*See* page 77.)

The ileo-cæcal fossa is a well-marked fossa present in nearly 74 per cent. of cases, and lying between the ileo-cæcal fold in front and the meso-appendix behind. This fossa is of some practical importance, as the vermiform appendix may become lodged in the fossa, thus possibly predisposing the subject to appendicitis.

Arterial Supply.—The cæcum is supplied by the ileo-colic branch of the superior mesenteric artery.

The Ileo-Cæcal Junction and Valve.—The terminal portion of the ileum ascends out of the pelvis first on the inner side of, and then rather posterior to the cæcum, to terminate in the inner and back part of the large intestine, at the junction of the cæcum and ascending colon.

The junction of the ileum with the large intestine is termed the *ileo-cæcal* or *ileo-colic junction*, and the orifice is guarded by a well-marked valve—the *ileo-cæcal* or *ileo-colic valve.*

The position of the ileo-cæcal orifice or valve may be indicated on the living subject by bisecting the outer edge of the rectus abdominis muscle by means of a line drawn from the umbilicus to the right anterior superior iliac spine. The point of bisection is termed Munro's point. (Keith.)

The Ileo-Cæcal Valve.—The ileo-cæcal valve is composed of two segments or folds, which project into the cavity of the large intestine. The upper segment is horizontal, the lower is oblique.

At each end of the ileo-cæcal orifice, which is about half an inch in length, the two segments of the valve unite and

are prolonged round the greater part of the interior of the large intestine in the form of two ridges, placed one on either side of the ileo-cæcal orifice. These ridges are termed the *fræna or the retinacula of the valve.*

On the external surface of the large intestine the position of the fræna or the retinacula is indicated by certain well-marked furrows termed the *frænal furrows.* These frænal furrows constitute the uppermost limits of the cæcum.

The ileo-cæcal valve is stated to be a purely mechanical valve, but the truth of the statement is doubtful.

The Vermiform Appendix.—The vermiform appendix is a small finger-like process which comes off from the inner and back part of the cæcum, about three-quarters of an inch (1·7 cm.) below the ileo-cæcal junction. Its average length is three and a half inches (9·2 cms.); its average diameter, quarter of an inch (6 mm.). These dimensions are subject to many variations.

Position.—The position of the vermiform appendix is exceptionally variable. One of the commonest positions is downwards into the pelvis; next in order of frequency come the retro-cæcal or retro-colic positions, where the appendix runs upwards either behind the cæcum or ascending colon, or possibly behind both. Lastly, it is not uncommon to find the appendix, pointing upwards and inwards, behind the ileum and its mesentery, towards the spleen. The most constant fact about the appendix is its relation to the cæcum mentioned in the preceding paragraph.

Surgically, the surest and readiest method of locating the vermiform appendix is to expose the anterior longitudinal muscular band of the cæcum and to follow this downwards, when it will always be found to lead to the appendix.

The base of the appendix, that is, its junction with the cæcum, may be mapped out on the living subject by a point about three-quarters of an inch below Munro's point.

Relations of the Vermiform Appendix to Peritoneum.—The vermiform appendix is always surrounded by peritoneum throughout its whole extent. There is usually a distinct fold of peritoneum—the meso-appendix—connecting the appendix to the enteric mesentery. (*See* page 77.)

It occasionally happens that when the vermiform appendix is situated within one or other of the retro-colic fossæ, the peritoneum surrounding the appendix becomes obliterated and disappears. Such an occurrence is rare.

Arterial Supply.—The vermiform appendix is supplied by the ileo-colic branch of the superior mesenteric artery.

The Ascending Colon.—The ascending colon is that part of the large intestine which ascends, on the right side, from the ileo-cæcal valve below to the hepatic flexure above. It is successively situated in the iliac, lumbar, and hypochondriac regions of the right side.

Relations.—The ascending colon is usually separated from the anterior abdominal wall by some coils of small intestine.

The posterior surface of the ascending colon is usually devoid of peritoneum, and is in direct contact with the fascia covering the quadratus lumborum muscle, and with the lower end of the anterior surface of the right kidney.

Relations of the Ascending Colon to Peritoneum.—The ascending colon is covered by peritoneum in front and on each side, and is thus bound down to the posterior abdominal wall, its posterior surface being entirely devoid of peritoneal lining.

It occasionally happens, though rarely, that the ascending colon is entirely surrounded by peritoneum, and it is in that case attached to the posterior abdominal wall by means of an *ascending meso-colon.*

The Retro-Colic Peritoneal Fossæ.—It sometimes happens that there are one, or at most, two well-marked peritoneal fossæ found behind the ascending colon. These fossæ are usually, but quite erroneously, termed the *retro-cæcal* or *post-cæcal fossæ.* The fossæ never lie behind the cæcum, therefore such terms are inadmissible.

The retro-colic fossæ are two in number, external and internal.

The *external retro-colic fossa* is very infrequently met with. Its existence depends on the presence of an ascending meso-colon. When that structure is present, a small but well-defined fossa is usually found running upwards behind the colon, between the two layers of the ascending meso-colon.

The *internal retro-colic fossa*, the more constant of the two, lies, when present, immediately internal to the peritoneum, which is reflected off the left side of the ascending colon, or immediately internal to the left layer of the ascending meso-colon when that structure exists.

The practical significance of these small fossæ depends on the fact that they may lodge the vermiform appendix, and so predispose the subject to appendicitis. It is extremely common to find the vermiform appendix lying in a retro-cæcal, or possibly a retro-colic, position, either with or without the retro-colic fossæ being present.

Arterial Supply.—The arterial supply to the ascending colon is derived from the right colic and ileo-colic branches of the superior mesenteric artery.

The Hepatic Flexure.—The hepatic flexure is the bend or flexure made by the large intestine at the junction of the ascending and transverse colons. The hepatic flexure passes forwards and to the left, and is in contact with the colic impression on the inferior surface of the right lobe of the liver external to the gall-bladder. It is situated in the right hypochondrium.

The Transverse Colon.—The transverse colon commences at the hepatic flexure in the right hypochondrium, and terminates at the splenic flexure in the left hypochondrium. Between these two points the transverse colon forms a loop which runs transversely across the upper part of the abdomen, successively occupying the right hypochondriac, umbilical, and left hypochondriac regions.

The loop formed by the transverse colon is directed downwards and forwards in such a way that its central portion is usually in contact with the anterior abdominal wall above the level of the umbilicus. Its position and relations to the anterior abdominal wall are, however, subject to the most numerous variations.

Relations.—The relations of the transverse colon are as follows:—

Above—

The liver and the gall-bladder
The greater curvature of the stomach.

In Front—

The great omentum.

Behind—

The second part of the duodenum.
Some coils of the jejuno-ileum.
The head of the pancreas.

Relations of the Transverse Colon to Peritoneum.—The transverse colon is entirely surrounded by peritoneum, with the exceptions of the lines along which the transverse meso-colon and the posterior two layers of the gastro-colic omentum are reflected from the gut.

The two layers of the transverse meso-colon are attached to the upper border of the transverse colon, from whence they pass respectively in front of and behind the gut to become continuous with the posterior two layers of the gastro-colic omentum.

The transverse colon, on account of the length of its meso-colon, is the most freely movable part of the large intestine. Its position, therefore, within the abdominal cavity is liable to many variations.

Arterial Supply.—The transverse colon is supplied by means of the middle colic branches from the superior mesenteric artery.

The Splenic Flexure.—The splenic flexure is the bend or flexure made by the large intestine at the junction of the transverse and descending colons. It is in intimate relation with the basal surface of the spleen and with the tail of the pancreas, and is situated in the left hypochondrium.

The splenic flexure differs from the hepatic flexure in its position and relations, and also in the facts that it is placed farther back and at a higher level in the left hypochondrium than is the hepatic flexure in the right.

The splenic flexure is connected to the diaphragm opposite the tenth or eleventh ribs by a crescentic double fold of peritoneum—the phrenico-colic ligament, which ligament supports the lower end of the spleen.

The Descending Colon.—The descending colon is that part of the large intestine which descends, on the left side, from the splenic flexure above to the sigmoid flexure below.

It is situated in the left hypochondriac and left lumbar regions.

Relations.—The descending colon first descends in direct non-peritoneal contact with the lower half of the external border of the left kidney. At the lower end of the left kidney the descending colon turns inwards somewhat, and then again descends near the outer border of the psoas muscle to a point opposite the iliac crest, where it terminates by becoming directly continuous with the sigmoid flexure.

The *posterior* relations of the descending colon are of more than usual importance on account of their bearings upon the operation of *lumbar colotomy,* as in that operation the descending colon is opened from behind. That portion of the descending colon which is in contact with the kidney lies immediately in front of the outer border of the quadratus lumborum. Between the lower end of the kidney and the iliac crest the gut turns inwards somewhat, and therefore lies altogether in front of the quadratus lumborum, just external to the outer border of the psoas muscle.

In front the descending colon is altogether concealed by coils of small intestine.

Relations of the Descending Colon to Peritoneum.—The descending colon is covered by peritoneum on its anterior and left surfaces only. The posterior and internal surfaces are entirely devoid of peritoneal covering.

A descending meso-colon is rarely present in the adult, but is almost constantly found in the fœtus.

In the fœtus the descending meso-colon is relatively long, and is attached by its root to the posterior abdominal wall, just internal to the left kidney.

Arterial Supply. — The descending colon derives its arterial supply from the left colic branch of the inferior mesenteric artery.

The Sigmoid Flexure.—The sigmoid flexure is that part of the large intestine which corresponds to the wall of the false pelvis. It commences opposite the iliac crest as the direct continuation of the descending colon, and terminates opposite the left sacro-iliac articulation by becoming directly continuous with the rectum.

The sigmoid flexure occupies the left iliac fossa, and very frequently the cavity of the true pelvis in addition. It forms a very variously developed loop which is sometimes tightly bound down to the walls of the iliac fossa, but which more frequently forms an omega-shaped curve which is very freely movable on account of its possessing a well-marked meso-sigmoid. Between these two extremes all variations are met with.

Under ordinary circumstances the sigmoid flexure is usually in contact with the anterior abdominal wall, just internal to the anterior superior iliac spine of the left side, whilst the loop which is formed by the flexure usually dips into the pelvic cavity and out again.

Relations of the Sigmoid Flexure to Peritoneum.—The sigmoid flexure is usually entirely surrounded by that double fold of peritoneum which constitutes the meso-sigmoid.

The Inter-Sigmoid Peritoneal Fossa.—On raising up the sigmoid flexure and its meso-sigmoid there is occasionally seen a small peritoneal fossa termed the *inter-sigmoid* fossa. The orifice of this fossa usually lies between the psoas and iliacus muscles, and the fossa itself extends upwards for a varying distance in the direction of the ureter.

Arterial Supply.—The arterial supply of the sigmoid flexure is derived from the sigmoid branches of the inferior mesenteric artery.

The Longitudinal Muscular Bands of the Large Intestine.—The longitudinal muscular coat of the large intestine tends to be aggregated together into certain distinct bands which are known as the *longitudinal muscular bands* of the large intestine.

The longitudinal muscular bands are especially well marked upon the cæcum and the colon generally, but tend to disappear upon the rectum, or at all events to become reduced in number.

The longitudinal muscular bands commence at the true cæcal apex, that is, the junction of the vermiform appendix with the cæcum. They are three in number, and as they ascend upon the cæcum and ascending colon they diverge

from one another and assume certain definite positions upon the gut wall, hence the names usually applied to them of anterior, posterior, and internal.

The *anterior* longitudinal muscular band runs upwards along the anterior wall of the cæcum and ascending colon, and in the case of the transverse colon corresponds to the attachment to that part of the gut of the gastro-colic omentum. This band forms the best surgical guide to the vermiform appendix in operations for the relief of appendicitis.

The *posterior* longitudinal muscular band lies behind the cæcum and ascending colon, and, in the case of the latter, corresponds to its attachment to the posterior abdominal wall.

The *internal* longitudinal muscular band lies on the inner side of the cæcum and ascending colon, and on the inferior side of the transverse colon. The appendices epiploicæ are best marked near this band.

All three longitudinal muscular bands are rather shorter than the large intestine itself, and hence they produce the characteristic sacculations in the walls of the large gut. If the longitudinal muscular bands were divided the sacculations would disappear.

The Internal Surface of the Large Intestine.—The mucous membrane of the large intestine differs from that of the small in being smooth and devoid of villi.

The crypts of Lieberkühn are present, but differ from those in the small intestine in being longer and more numerous, and in containing a larger number of mucus cells.

Lymphoid nodules, resembling the solitary glands of the small intestine, are present in the large intestine, being especially numerous in the cæcum and vermiform appendix; in fact, the submucosa of the latter is simply a mass of lymphoid tissue.

Differences between the Small and the Large Intestines.—The following differences between the small and large intestines must be noted:—

1. Differences in length and diameter.

2. The large intestine is sacculated, the small intestine is not.

3. The large intestine possesses three well-marked longitudinal bands; these are not present in the small intestine, their presence in the large intestine producing the sacculations just referred to.

4. The large intestine is characterised by the presence of appendices epiploicæ, whilst the small intestine has none.

5. The greater portion of the small intestine is freely movable, the greater portion of the large intestine is not.

Arterial Supply of the Alimentary Canal. — The alimentary canal in the abdomen and pelvis is supplied almost, but not quite entirely, by the three most important unpaired branches of the abdominal aorta, namely, the cœliac axis, the superior mesenteric artery, and the inferior mesenteric artery.

The cœliac axis also supplies the liver, the gall-bladder, the spleen, and the pancreas.

The Cœliac Axis.—This vessel is a short, wide vessel, which arises from the front of the abdominal aorta, between the two crura of the diaphragm, opposite the upper border of the first lumbar vertebra.

It runs horizontally forwards just above the upper border of the pancreas, and to the left side of the Spigelian lobule of the liver, and after a course of not more than half an inch it terminates by dividing into its three terminal branches—the coronary artery, the splenic artery, and the hepatic artery.

A. **The Coronary Artery.**—This vessel, the smallest branch derived from the cœliac axis, runs upwards and to the left, behind the peritoneum of the lesser sac, until it reaches the cardiac orifice of the stomach, where it turns sharply forwards and downwards, and, entering between the two layers of the gastro-hepatic omentum, passes from above downwards and then from left to right along the lesser curvature of the stomach, supplying both surfaces of that viscus, and anastomosing with the pyloric branch of the hepatic artery.

It gives off some œsophageal branches to the œsophagus and gastric branches to the stomach.

B. **The Splenic Artery.**—This vessel is the largest branch from the cœliac axis; it pursues a tortuous course along the upper border of the pancreas, across the front of the left kidney, and terminates in the hilum of the spleen by dividing into its several splenic branches.

The vessel lies throughout behind the peritoneum, forming the posterior wall of the lesser sac, and eventually reaches the spleen by passing between the layers of the lieno-renal ligament.

The branches of the splenic artery are as follows:—

- Pancreatic branches.
  - (*a*) Arteria pancreatica magna.
  - (*b*) Arteriæ pancreaticæ parvæ.
- Gastric branches.
  - (*a*) The vasa brevia.
  - (*b*) The left gastro-epiploic artery.
- Terminal or splenic branches.

Pancreatic Branches.—These run from left to right in the substance of the pancreas. The largest of these accompanies the duct of the pancreas, *i.e.* the duct of Wirsung, and is known as the *arteria pancreatica magna;* the smaller branches are termed the *arteriæ pancreaticæ parvæ.*

The Short Gastric Branches, or the Vasa Brevia.—The short gastric branches, or the vasa brevia, run upwards in the gastro-splenic omentum, along the greater curvature of the stomach, to the fundus, where they anastomose with the coronary artery.

The Left Gastro-Epiploic Artery.—The left gastro-epiploic artery runs from left to right along the greater curvature of the stomach, between the two anterior layers of the great omentum, and anastomoses with the right gastro-epiploic artery from the gastro-duodenal branch of the hepatic artery. It supplies the stomach and great omentum.

Splenic or Terminal Branches. — Splenic or terminal branches, about seven in number, supply the spleen, which viscus they reach by passing between the two layers of the lieno-renal ligament.

C. **The Hepatic Artery.**—This vessel first passes forwards and to the right, above the upper border of the pancreas and below the foramen of Winslow, to the pyloric end of the stomach, where it gives off its gastro-duodenal branch.

The artery then changes its direction, and turns upwards in the right lateral free margin of the gastro-hepatic omentum and in front of the foramen of Winslow, to terminate near the transverse fissure of the liver by dividing into right and left hepatic arteries for the supply of the corresponding lobes of the liver.

Within the gastro-hepatic omentum the hepatic artery lies in front of the portal vein and immediately to the left of the common bile duct.

The branches of the hepatic artery are as follows:—

- The pyloric artery.
- The gastro-duodenal artery.
    - (*a*) Superior pancreatico-duodenal.
    - (*b*) Right gastro-epiploic.
- Terminal or hepatic arteries.
    - (*a*) Right.
    - (*b*) Left.

The Pyloric Artery.—This vessel descends from its origin to the upper border of the pylorus, and then runs from right to left along the lesser curvature of the stomach, between the two layers of the gastro-hepatic omentum, to anastomose with the coronary artery.

The Gastro-Duodenal Artery.—This vessel arises from the hepatic artery near the pylorus, and descends behind the first part of the duodenum, to terminate at its lower border by dividing into the superior pancreatico-duodenal artery and the right gastro-epiploic artery.

(*a*) *The superior pancreatico-duodenal artery* descends between the duodenum and the pancreas, supplying both those viscera, and anastomosing with the inferior pancreatico-duodenal artery from the superior mesenteric artery.

(*b*) *The right gastro-epiploic artery* runs from right to left along the greater curvature of the stomach, between the two anterior layers of the great omentum. It supplies the stomach and omentum, and anastomoses with the left gastro-epiploic artery.

The Right and Left Hepatic Arteries.—The right and left hepatic arteries enter the substance of the liver at the transverse fissure. The right hepatic artery very frequently gives off the *cystic artery* to the gall-bladder.

The Superior Mesenteric Artery.—This vessel supplies almost the whole of the small intestine and half of the large intestine.

It arises from the front of the abdominal aorta, opposite the first lumbar vertebra, quarter of an inch below the cœliac axis, and behind the pancreas and splenic vein. It passes in front of the left renal vein, and makes its appearance between the neck and head of the pancreas. Descending in front of the head of the pancreas and third part of the duodenum it passes between the two layers of the enteric mesentery, and, taking a curved course to the right, ends near the ileo-cæcal junction by anastomosing with one of its own branches, the ileo-colic artery.

The artery is accompanied by the superior mesenteric vein which lies to its right side, and by the superior mesenteric plexus of nerves which surrounds the vessel.

The branches of the superior mesenteric artery are as follows:—

The inferior pancreatico-duodenal artery.
The vasa intestini tenuis arteries.
The ileo-colic artery.
The right colic artery.
The middle colic artery.

The Inferior Pancreatico-Duodenal Artery.—This small vessel runs between the pancreas and the duodenum, both of which it supplies. It terminates by anastomosing with the superior pancreatico-duodenal artery from the gastro-duodenal branch of the hepatic.

The Vasa Intestini Tenuis Arteries.—These vessels, some twelve or more in number, arise from the convex or left side of the artery. They form a remarkable series of arterial arcades by their various subdivisions, and supply the jejuno-ileum.

The Ileo-Colic Artery.—This vessel runs downwards and to the right, to the cæcum. It supplies the cæcum, the appendix, the termination of the ileum, and the ascending colon. It anastomoses with the superior mesenteric artery itself, and with the right colic artery, by means of its descending and ascending branches respectively.

The Right Colic Artery.—This vessel leaves the enteric mesentery at its root, and then passes to the right behind the parietal peritoneum on the posterior abdominal wall, to the ascending colon, which it supplies. It anastomoses with the ileo-colic and middle colic arteries.

The Middle Colic Artery.—This vessel runs forwards between the two layers of the transverse meso-colon to supply the transverse colon. It anastomoses with the right colic artery, and with the left colic artery from the inferior mesenteric artery.

The superior mesenteric artery and its branches supply the third and fourth parts of the duodenum, the jejuno-ileum, the cæcum and appendix, the ascending colon, the hepatic flexure, the transverse colon, and the splenic flexure.

Those branches which supply the duodenum and ascending colon have a layer of peritoneum on their anterior surfaces only; the others lie between two layers of peritoneum.

The Inferior Mesenteric Artery.—This vessel arises from the front of the abdominal aorta, one and a half inches above its bifurcation. It passes slightly to the left and then downwards close to the aorta. Passing in front of the left common iliac vessels as the superior hæmorrhoidal artery, it is continued to the rectum.

The branches of the inferior mesenteric artery are as follows:—

The left colic artery.
The sigmoid arteries.
The superior hæmorrhoidal artery.

The Left Colic Artery.—This vessel passes to the left, behind the peritoneum and usually in front of the left kidney, to the descending colon. It anastomoses with the middle colic artery from the superior mesenteric artery, and with the sigmoid arteries.

The Sigmoid Arteries.—These vessels run obliquely to the sigmoid flexure, which they supply; they enter the meso-

sigmoid to reach the gut, and anastomose with the left colic and superior hæmorrhoidal vessels.

The Superior Hæmorrhoidal Artery.—This is considered with the pelvis. (*See* page 169.)

The inferior mesenteric artery and its branches supply the descending colon, the sigmoid flexure, and the rectum, that is, the lower half of the large intestine.

The Portal System of Veins.—The venous return from the *chylopoictic viscera*, that is, from the alimentary canal and the pancreas, as well as that from the *spleen* and *gall-bladder*, passes through the vena portæ. In discussing, therefore, the venous return from the alimentary canal within the abdomen and pelvis, the whole of this most important portal system of veins must be considered together.

The venous blood which passes through the portal vein differs from all other venous blood in several most important respects.

Firstly, it passes through two sets of capillaries—the ordinary systemic capillaries and the portal capillaries within the liver.

Secondly, there are no valves within the portal system or its more important tributaries.

Thirdly, the blood which enters the liver through the portal system, as well as that which enters the liver through the hepatic arteries, leaves the liver by a common course, namely, the hepatic veins, which terminate in the inferior vena cava, without having had any existence outside the liver.

The Portal Vein, or the Vena Portæ.—This important vein is three inches long. It is formed behind the neck of the pancreas, just to the left of the inferior vena cava at the level of the first lumbar vertebra, by the junction of the splenic vein with the superior mesenteric vein.

Having been formed in this manner, the portal vein passes upwards and to the right, behind the neck of the pancreas and the first part of the duodenum, and then between the two layers of the gastro-hepatic omentum to the transverse fissure of the liver, where it terminates by dividing into its right and left divisions which enter the respective lobes of the liver; whilst the vein is within the gastro-hepatic omentum, it lies immediately behind the common bile duct and the hepatic artery.

In the longitudinal fissure of the liver the left division of the portal vein is joined anteriorly by the so-called *round ligament of the liver*, that is, by the remains of the umbilical vein of the fœtus; whilst to the right of this, and passing backwards from the left division of the portal vein, there is the obliterated *ductus venosus*, which runs backwards to the inferior vena cava.

Direct Tributaries of the Portal Vein—

1. The superior mesenteric vein.
2. The splenic vein.

These two vessels by their union form the portal vein.

3. The pyloric vein from the stomach.
4. The coronary vein from the stomach.
5. The cystic vein from the gall-bladder.

The Superior Mesenteric Vein.—This vein lies to the right side of its artery, and has the same relations throughout; it terminates behind the neck of the pancreas by joining the splenic vein to form the portal vein.

Its tributaries correspond exactly to the branches of its artery, but, in addition, the vein receives the *right gastro-epiploic vein* from the greater curvature of the stomach.

The Splenic Vein.—The splenic vein accompanies its artery, but lies at a lower level, and is therefore behind the pancreas, not at its upper border like the artery; it terminates behind the neck of the pancreas in the manner already indicated.

Its tributaries correspond to those of the artery, but, in addition, the vein receives the *inferior mesenteric vein*, which opens into the splenic usually at a right angle.

The Inferior Mesenteric Vein.—The inferior mesenteric vein commences at the anus, as the superior hæmorrhoidal vein; passing upwards as the inferior mesenteric vein, it lies to the left of its artery, and, disappearing behind the pancreas, terminates in the splenic vein.

Its tributaries correspond exactly to the branches of its artery.

The *pyloric, coronary, and cystic veins* correspond exactly to their respective arteries.

The Accessory Glands to the Alimentary Tract.—The accessory glands to the alimentary tract comprise the liver and pancreas. In discussing the shape of these glands, as well as those of the other abdominal viscera, the student will do well to remember that in all probability the shape of these viscera varies considerably during life, and that the various shapes, as described by anatomists, are only to be taken as more or less approximating to the actual living condition.

The Liver.—The liver is the largest gland in the body; it weighs about fifty to sixty ounces, that is, about one thirty-sixth of the total body weight, though in the fœtus its proportionate weight is greater.

Position.—The liver occupies the three regions of the costal zone, that is, the right hypochondriac region, the epigastrium, and the left hypochondriac region. The greater part of the liver is, however, contained within the epigastrium.

Shape.—The shape of the liver varies considerably, even under ordinary physiological conditions; but, for descriptive purposes, the liver is compared by Symington to a right-angled triangular prism with the right angle rounded off.

The liver has, then, five surfaces—an anterior surface, a posterior surface, a right lateral surface or base, a superior surface, and an inferior surface.

The liver is further unequally but naturally subdivided into a right and left lobe; the divisions between these two lobes are mentioned under each surface respectively.

The Right Lateral Surface or Base.—This is usually convex in every direction. Its area corresponds to the lateral portions of the seventh, eighth, ninth, tenth, and eleventh costal arches, from which it is separated by the diaphragm and the thin basal margin of the right lung.

The Superior Surface.—This surface is smooth, is accurately moulded to the under surface of the diaphragm, and is covered by peritoneum.

Near the middle line of the body this surface gives attachment to the falciform ligament, which thus indicates, on this surface, the division of the liver into right and left lobes.

The slight concave depression on this surface of the liver is produced by the heart and pericardium pressing on the liver through the diaphragm.

The Anterior Surface.—This is the largest of the liver surfaces. It is smooth and distinctly triangular in outline, and is separated from the inferior surface of the liver by a very definite and sharp border, which can frequently be felt on the living subject.

This surface is smooth and covered by peritoneum, and the division into right and left lobes is made by the falciform ligament, and below that by the umbilical notch.

In the lower border of this surface, and to the right of the umbilical notch, there is a second notch for the gall-bladder.

The Posterior Surface.—This surface is also distinctly triangular in outline, but is very uneven, and is only partially covered by peritoneum. On this surface there are certain very definite parts to be recognised. Passing from right to left, these are as follows:—

A large non-peritoneal area.
The fissure for the inferior vena cava.
The Spigelian lobule.
The fissure of the ductus venosus.
A portion of the left lobe of the liver.

The Large Non-Peritoneal Area.—This non-peritoneal area is situated on the right lobe, and is convex, except at its lower and mesial angle, which is indented by the right suprarenal capsule.

It is bounded above and below by the lines of reflection of the peritoneum on to the diaphragm; this part of the liver is devoid of peritoneum, and is in direct contact with the diaphragm; it is separated below, from the inferior surface of the liver, by a sharp margin, which runs obliquely downwards and outwards, following the line of the eleventh and twelfth ribs.

The Fissure for the Inferior Vena Cava.—This is a deep

groove placed on the right side of the Spigelian lobule. It lodges the inferior vena cava, which is sometimes altogether covered in by a bridge of liver substance which crosses from one side of the fissure to the other.

The Spigelian Lobule.—This is a nearly vertical and quadrilateral area on the posterior surface of the liver, which is placed opposite the tenth and eleventh dorsal vertebræ. It rests against the diaphragm, from which it is only separated by two layers of peritoneum belonging to the lesser sac.

The right border of the Spigelian lobule is in contact with the fissure for the inferior vena cava.

The left border is separated from the left lobe of the liver by the fissure of the ductus venosus. The upper end of this border is crossed obliquely by the œsophagus passing into the cardia of the stomach.

The lower border of the Spigelian lobule is distinctly notched; the part to the right of the notch joins the caudate lobule on the inferior surface of the liver; the part to the left of the notch ends in a small tubercle, the *tuber papillare.*

The Fissure of the Ductus Venosus.—This fissure forms the posterior part of the longitudinal fissure of the liver, and indicates, on this surface of the liver, the division into right and left lobes. It is occupied by a fibrous cord, the remains of the ductus venosus, and gives attachment, in part, to the gastro-hepatic omentum.

A Portion of the Left Lobe of the Liver.—This lies in front of the cardia of the stomach and the gastro-hepatic omentum. It passes almost insensibly into the inferior surface of the liver. The concave groove lodges the œsophagus.

The Inferior Surface.—The inferior surface of the liver is uneven, and looks downwards, backwards, and to the left. With the exception of the parts occupied by the gall-bladder and the transverse fissure, it is entirely covered by peritoneum.

This surface is divided into right and left lobes by means of the anterior part of the longitudinal fissure, or the fissure of the umbilical vein. The under surface of the right lobe is further subdivided into three unequal areas by means of the transverse fissure of the liver and the fissure for the gall-bladder. This division of the inferior surface of the liver may be summarised thus:—

The left lobe.
The right lobe.
  The lobulus quadratus.
  The lobulus caudatus.
  A large unnamed area to the right of these two.

The Inferior Surface of the Left Lobe.—This is smooth and concavo-convex; it is accurately moulded to the anterior surface of the stomach; the prominent convexity is termed the *omental tuberosity*, and is in contact with the lesser curvature of the stomach and with the gastro-hepatic omentum.

The Lobulus Quadratus.—This is a well-defined area which has the following boundaries:—

In Front.—The anterior sharp margin of the liver.
Behind.—The transverse fissure of the liver.
To the Right.—The fissure for the gall-bladder.
To the Left.—The umbilical fissure.

The quadrate lobule is in contact with the pylorus and first part of the duodenum.

The Lobulus Caudatus.—This is a narrow area lying behind the transverse fissure of the liver, and immediately above the foramen of Winslow. It connects the Spigelian lobule with the large unnamed area on the inferior surface of the right lobe. It should be remembered that the lobulus caudatus lies between two important veins—the portal vein in front and the inferior vena cava behind.

The Large Unnamed Area.—On this area there are three distinct concave impressions—anterior, posterior, and internal. The anterior impression is in contact with the hepatic flexure; the posterior with the anterior surface of the right kidney and with the lower or basal portion of the right suprarenal capsule; the internal impression is in contact with the second part of the duodenum.

The Fissures of the Liver.—The fissures of the liver are as follows:—

The transverse fissure.

The longitudinal fissure.
  (*a*) Fissure of the obliterated umbilical vein.
  (*b*) Fissure of the ductus venosus.
The fissure for the inferior vena cava.
The fissure for the gall-bladder.

The Transverse Fissure of the Liver.—This important fissure lies between the quadrate lobule in front and the caudate lobule behind. It is situated on the inferior surface of the right lobe, and transmits the hepatic arteries, the portal vein, and the hepatic ducts. It is about two inches long, and joins the longitudinal fissure almost at a right angle.

The Longitudinal Fissure.—This fissure is found on both the inferior and the posterior surfaces of the liver.

That portion which occupies the inferior surface is known as the *umbilical fissure.* It lies between the quadrate lobule and the left lobe of the liver, and extends from the anterior border of the liver backwards to the left extremity of the transverse fissure.

The umbilical fissure contains, in the fœtus, the umbilical vein, and in the adult, the fibrous remains of that vein, which constitutes the *round ligament of the liver*, or the *obliterated umbilical vein.*

This fissure is not infrequently bridged over by liver substance, the *pons hepatis,* which converts the fissure into a canal.

That portion of the longitudinal fissure which occupies the posterior surface of the liver is also known as the *fissure of the ductus venosus.* It lies between the Spigelian lobule and the left lobe. It lodges the ductus venosus in the fœtus, and in the adult the atrophied remnant of that structure.

The Fissure for the Inferior Vena Cava.—(*See* page 108.)

The Fissure for the Gall-Bladder.—This lies on the inferior surface of the right lobe, between the quadrate lobule and the unnamed area. It extends from the anterior border of the liver backwards to the right extremity of the transverse fissure. It lodges the gall-bladder.

The Peritoneal Ligaments of the Liver.—The peritoneal ligaments of the liver are four in number—the coronary ligament, the right and left lateral ligaments, and the falciform ligament. In addition to these there is a fifth non-peritoneal ligament, the *ligamentum teres.*

The Coronary Ligament.—The coronary ligament is the name given to the two layers of peritoneum which are reflected off the liver above and below the bare area on its posterior surface.

The peritoneum on the superior surface of the liver is reflected off the liver on to the diaphragm immediately above the bare area, and so constitutes the *upper layer* of the coronary ligament.

The peritoneum on the inferior surface of the liver is reflected off on to the upper part of the right suprarenal capsule and inferior vena cava immediately below the bare area of the liver, and so constitutes the *lower layer* of the coronary ligament.

The two layers of the coronary ligament are therefore separated from each other by the bare area of the liver.

The Right Lateral Ligament.—The right lateral ligament is the small double peritoneal fold which is formed at the right extremity of the bare area of the liver by the apposition of the two layers of the coronary ligament.

The Left Lateral Ligament.—This ligament, longer and more distinct than the right lateral ligament, is somewhat triangular in outline. It passes from the posterior part of the superior surface of the left lobe of the liver backwards to the diaphragm.

The upper layer of this ligament becomes continuous with the left layer of the falciform ligament.

The Falciform Ligament.—This is a somewhat triangular fold, composed of two layers of peritoneum. Its right layer becomes continuous with the upper layer of the coronary ligament, the left layer with the upper layer of the left lateral ligament.

Its anterior border is attached to the diaphragm and the anterior abdominal wall as low down as the umbilicus.

Its posterior border is attached to the superior and anterior surfaces of the liver, and on these surfaces it serves to divide the liver into right and left lobes.

The base is free, and contains within it the round ligament, the remains of the umbilical vein.

The Round Ligament.—This, as has been stated, is not a

peritoneal ligament; it is the remains of the obliterated umbilical vein.

The obliterated umbilical vein, or the round ligament of the liver, is a fibrous cord which passes from the umbilicus upwards, backwards, and slightly to the right between the two layers of the falciform ligament, to the umbilical fissure on the inferior surface of the liver. It terminates, in the adult, by joining the left division of the portal vein.

The Vascular Supply of the Liver.—Blood enters the liver from two sources, the hepatic artery and the portal vein. Both these vessels enter the liver by means of the transverse fissure. The relations of the various structures which enter or leave the liver at this point are—bile-duct to the right, hepatic artery to the left, and the portal vein behind and between these two structures. All the blood which enters the liver, no matter from what source, leaves the liver by means of the hepatic veins, and thus enters the inferior vena cava. The hepatic veins have no existence outside the liver.

The Excretory Apparatus of the Liver.—By this is meant the various passages for the bile. It includes the following parts:—

The gall-bladder.
The cystic duct.
The hepatic duct.
The common bile-duct.

The Gall-Bladder.—This is a pear-shaped sac which is lodged in the fissure for the gall-bladder on the inferior surface of the right lobe of the liver.

The enlarged anterior end, or the *fundus*, is, in 50 per cent. of cases, in contact with the anterior abdominal wall in the vicinity of the ninth right costal cartilage, in or immediately external to the right lateral line. It is covered by peritoneum, and is directed downwards, forwards, and to the right, in such a way that it projects slightly beyond the anterior border of the liver.

The upper surface of the gall-bladder is in direct non-peritoneal contact with the liver, to which it is connected by loose areolar tissue.

The under surface of the gall-bladder is in contact, from before backwards, with the commencement of the transverse colon and with the first part of the duodenum. It is covered by peritoneum throughout.

The neck of the gall-bladder gradually becomes constricted and curved like the letter S, and, bending downwards, terminates in the cystic duct near the right end of the transverse fissure.

The Cystic Duct.—The cystic duct is about one and a half inches in length. It runs backwards, downwards, and to the left, and unites with the hepatic duct to form the *common bile-duct.*

The Hepatic Duct.—This is formed by the junction of the *right and left hepatic ducts* from the right and left lobes of the liver. These issue from the transverse fissure, and unite at a very obtuse angle to form the hepatic duct.

Having been formed in this way, the hepatic duct passes downwards for two inches in the gastro-hepatic omentum, and terminates, by being joined at an acute angle by the cystic duct, to form the *common bile-duct.*

The Common Bile-Duct, or the Ductus Communis Cholédochus.—The common bile-duct is formed by the junction, at an acute angle, of the hepatic and cystic ducts.

It passes downwards and backwards between the two layers of the gastro-hepatic omentum, lying here to the right of the hepatic artery, and in front of the portal vein. It then passes behind the first part of the duodenum and the head of the pancreas, to end in the second part of the duodenum.

Just before its termination it is joined by the duct of the pancreas, which opens, in common with it, into the duodenum. The common bile-duct is about three inches long.

The Pancreas.—The pancreas is an elongated gland which lies across the posterior abdominal wall, behind the stomach, and opposite the first and second lumbar vertebræ.

It occupies the epigastrium and left hypochondrium, the greater part of the gland lying in the epigastrium.

The pancreas is described by Symington as possessing a head, a neck, a body, and a tail.

The Head of the Pancreas.—This is disc-shaped and flattened from before backwards. It is surrounded by the second, third, and fourth parts of the duodenum, and lies in front of the first and second lumbar vertebræ.

Its relations are as follows:—

In Front.—

The transverse colon.
The transverse meso-colon.
Parts of the superior mesenteric artery and vein.
The superior and inferior pancreatico-duodenal arteries.

Behind.—

The inferior vena cava.
The left renal vein.
The aorta.
The common bile-duct.

The Neck of the Pancreas.—This is about one inch long. It passes upwards, forwards, and to the left, to join the body.

Its relations are as follows:—

In Front and to the Outer Side.—

The first part of the duodenum, and the pylorus when the stomach is distended.

Behind.—The commencement of the portal vein.

The Body of the Pancreas.—This is about four inches long, and in sagittal section is very distinctly triangular. It may therefore be described as possessing three surfaces—anterior, posterior, and inferior. Its two most important borders are the superior and the anterior.

(*a*) *The Anterior Surface.*—This is concave, and is in contact with the stomach, the peritoneum of the lesser sac alone intervening. At the right end of this surface there is usually a well-marked upward projection, termed the *omental tuberosity.*

(*b*) *The Posterior Surface.*—This lies in front of the aorta, the origin of the superior mesenteric artery, the pillars of the diaphragm, the splenic vein, the left kidney and its vessels, and the left suprarenal capsule.

(*c*) *The Inferior Surface.*—This rests upon the duodeno-jejunal flexure and the termination of the transverse colon.

(*d*) *The Superior Border.*—The superior border is in relation to the cœliac axis and the hepatic artery; whilst, lastly, the splenic artery pursues a tortuous course from right to left along this border.

(*e*) *The Anterior Border.*—At this border the two layers of peritoneum which form the transverse meso-colon reach the posterior abdominal wall; the upper layer passes upwards in front of the anterior surface of the pancreas, the lower layer passes backwards along the inferior surface. The posterior surface of the pancreas is thus the only one of its three surfaces which is devoid of peritoneum.

The Tail of the Pancreas.—The tail of the pancreas bends upwards slightly to come into contact with the basal surface of the spleen. Its lower surface touches the splenic flexure of the colon.

The Duct of Wirsung.—The principal excretory duct of the pancreas is the duct of Wirsung. It runs from left to right in the substance of the gland, and terminates by joining the common bile-duct to open into the second part of the duodenum by an orifice common to both ducts.

The duct of Wirsung is accompanied in the substance of the pancreas by the arteria pancreatica magna.

The Ductless Glands of the Abdomen.—The principal ductless glands of the abdomen are the spleen and the suprarenal capsules. The latter are considered with the kidneys. (*See* page 122.)

The Spleen.—The spleen is obliquely situated behind the stomach. Its upper end occupies the epigastrium, its lower end the left hypochondrium. Its longest axis, which is directed from above downwards and outwards and slightly forwards, corresponds very closely to the direction of the tenth rib.

The spleen is described by Cunningham as being an irregular tetrahedron possessing four surfaces, three borders, and an upper extremity or angle.

The surfaces are termed respectively phrenic, renal, gastric, and basal.

The Phrenic Surface.—This, the largest of the four surfaces, is convex, and lies against the diaphragm. It corresponds very closely to the ninth, tenth, and eleventh

ribs, from which it is separated by peritoneum, diaphragm, pleura, and left lung.

The Renal Surface.—This surface is concave and narrow. It is in contact with the upper half of the outer border of the left kidney, and looks inwards and downwards.

The Gastric Surface.—This is concave, and looks forwards and inwards. It is in contact with the posterior surface of the stomach near the fundus, from which it is only separated by peritoneum.

On this surface there is the *hilum* of the spleen, where the various vessels enter or leave the organ.

The Basal Surface.—This surface forms the lower end of the spleen; it is blunted and somewhat triangular in outline. It is in contact with the tail of the pancreas, the splenic flexure of the colon, and with the phrenico-colic ligament. Under normal conditions the lower end of the spleen is situated on the tenth rib in the mid-axillary line.

The Upper End of the Spleen.—This is directed somewhat inwards, and is in contact with the left suprarenal capsule. Under normal conditions it lies on the tenth rib, one inch from the middle line of the body, that is, from the vertebral spines.

The renal, gastric, and basal surfaces meet at a blunt and prominent angle, termed by Cunningham the *internal basal angle.* From this angle three ridges radiate in different directions. One of these ridges is prominent and well defined. It runs upwards between the gastric and renal surfaces to the upper end of the spleen. A second ridge passes backwards between the renal and basal surfaces to the *posterior basal angle.* A third indistinct and badly defined ridge passes forwards between the gastric and basal surfaces to the *anterior basal angle.* These three ridges are not to be confused with the *borders* of the spleen.

The *borders* of the spleen are three in number—anterior, posterior, and inferior.

The *anterior border* of the spleen is notched. It separates the phrenic and gastric surfaces.

The *posterior border* separates the phrenic and renal surfaces of the spleen, and corresponds to the lower border of the eleventh rib.

The *inferior border* intervenes between the phrenic and basal surfaces.

The three borders of the spleen, and the three ridges which radiate from its internal basal angle, serve to define very accurately the various surfaces of the spleen. The basal surface, for example, is that part which is accurately circumscribed by the inferior border of the spleen, and by the two ridges which pass from the internal basal angle to the anterior and posterior basal angles respectively.

Relations of the Spleen to Peritoneum.—The spleen is almost entirely surrounded by peritoneum. It is connected to the stomach near its fundus by the *gastro-splenic omentum,* which leaves the spleen at the hilum on the gastric surface. The spleen is also connected to the left kidney and diaphragm by the short *lieno-renal ligament.*

The Urinary Organs within the Abdomen.—The urinary organs within the *abdomen* comprise the two kidneys and the ureters; associated with the kidneys, though with no allied functions, are the two ductless glands, the suprarenal bodies.

The Kidneys.—The two kidneys are deeply situated in the loins, on either side of the vertebral column and behind the peritoneum. They are surrounded by a capsule of loose areolar tissue, and lie on a level with the bodies of the last dorsal and first two lumbar vertebræ, the right kidney being somewhat lower than the left.

The right kidney lies in the right hypochondrium, the epigastrium, the right lumbar region, and the umbilical region. The left kidney only lies in the left hypochondrium and the epigastrium.

Both kidneys are obliquely situated, in such a way that their long axes pass from above downwards and slightly outwards, the upper ends being rather nearer the middle line than the lower. They are further slightly rotated upon themselves, in such a manner that the anterior surface of each kidney looks outwards as well as forwards.

Each kidney is about four inches in length and about two and a half inches in breadth.

The left kidney is usually rather longer and narrower than the right.

The average weight is about four and a half ounces in the male and rather less in the female.

Each kidney is characteristically reniform in shape, and may be described as possessing two surfaces, anterior and posterior; two borders, outer and inner; two extremities, upper and lower.

The Posterior Surface.—The relations of the posterior surfaces of both kidneys are nearly identical.

The posterior surface of each kidney rests upon the diaphragm and its arcuate ligaments, the last rib, the anterior lamella of the lumbar aponeurosis which separates the kidney from the quadratus lumborum muscle, and upon the psoas muscle, which last separates the kidney from the transverse processes of the first and second lumbar vertebræ.

Below the last rib, the last dorsal nerve, accompanied by the abdominal branch of the first lumbar artery, and the ilio-inguinal and ilio-hypogastric nerves pass out behind the kidney.

Besides these immediate posterior relations of the kidneys there are certain other most important points to be noted.

The right kidney does not usually extend upwards beyond the upper border of the twelfth rib, whereas the upper end of the left kidney usually reaches as high as the lower border of the eleventh rib, or even higher, and therefore comes to lie in front of the eleventh intercostal space, from which it is separated only by the diaphragm and the pleura. This relation of pleura to the left kidney, and occasionally to the right kidney, must be particularly noted.

Lastly, where the kidney is in contact with the diaphragm, there is by no means unusually an interval between the vertebral and costal origins of that muscle, and then the posterior surface of the kidney is only separated from the pleural cavity by areolar tissue. The whole of the posterior surface of each kidney is entirely devoid of peritoneum, and is embedded in areolar and adipose tissue.

The Anterior Surface.—On account of the obliquity of the kidney, its anterior surface looks outwards as well as forwards. The relations differ on the two sides.

The Right Kidney.—The upper two-thirds of the anterior surface of the right kidney is in contact with the renal impression on the inferior surface of the right lobe of the liver, and is covered by peritoneum.

Near the hilum of the kidney, at its inner border, the second part of the duodenum is in direct non-peritoneal contact with the kidney.

External to the duodenal impression, the anterior surface is in direct non-peritoneal contact with the ascending colon.

Lastly, a small portion of the lower end of the kidney, internal to the colic impression, is peritoneal, and is in contact with some coils of the small intestine.

The Left Kidney.—The anterior surface of the left kidney is crossed transversely about the level of the hilum by the pancreas and splenic vessels, with which it is in direct non-peritoneal contact.

Above this it is only separated from the stomach by peritoneum belonging to the lesser sac.

Below the area for the pancreas it is in contact with the coils of the small intestine, and is peritoneal.

The External Border.—Here also the relations of the two kidneys differ somewhat.

The Right Kidney.—The upper two-thirds is in contact with the liver, the lower third with the ascending colon.

The Left Kidney.—The upper half of the external border is in contact with the renal surface of the spleen, from which it is only separated by peritoneum.

The lower half is in direct non-peritoneal contact with the descending colon.

The Internal Border.—The internal border of each kidney presents, about its middle third, the hilum, the order of the structures in the hilum being, from before backwards—vein, artery, ureter.

On the left side the suprarenal capsule usually extends down the inner border as far as the hilum.

The Upper End.—The upper end of each kidney is surmounted by the suprarenal capsule, which is in direct non-peritoneal contact with the kidney. The capsule of the left side descends lower on the inner border and anterior surface of the left kidney than it does on the right.

The Lower End.—The lower ends are rather smaller than the upper; they are situated just above the level of the iliac crests, the lower end of the right kidney being usually lower than that of the left kidney. The interval which separates the lower ends of the kidneys from the iliac crests is usually stated to be about two inches, but it is probably much less than this, and in any case is very variable.

The Hilum of the Kidney.—The hilum of the kidney is a deep longitudinal fissure for the passage to and from the kidney of the renal vessels, ureter, nerves, and lymphatics, and which fissure is situated on the middle third of the internal border.

The hilum of the kidney is bounded in front and behind by a thick prominent lip of renal tissue, and leads into a deep recess termed the *renal sinus*.

The principal structures found in the hilum of the kidney are, in order from before backwards—

The renal vein.
The renal artery.
The ureter.

As the ureter is the most posterior structure in the hilum, and passes downwards, it is quite easy to refer a kidney to the side to which it belongs.

Relations of the Kidneys to Peritoneum.—The kidneys lie altogether behind the peritoneum, their posterior surfaces are therefore quite devoid of peritoneal lining.

The anterior surface of the right kidney is covered by peritoneum over its hepatic and small intestine areas, but is non-peritoneal elsewhere.

The anterior surface of the left kidney is covered by peritoneum throughout, with the exception of its pancreatic, descending colon, and suprarenal areas, which are non-peritoneal.

Mobility of the Kidney.—As the kidney lies behind the peritoneum and is only embedded in loose areolar tissue, slight changes in the position of the kidney are by no means uncommon.

If the kidney becomes freely movable behind the peritoneum it gives rise to what is known as *movable kidney*, whilst if the kidney becomes so movable as to pass forward, invaginating the peritoneum before it, it is termed *floating kidney*, and is then connected to the posterior abdominal wall by a distinct *meso-nephron.*

The Inclined Planes of the Kidney.—Cunningham has endeavoured to show that, owing to the visceral pressure to which the kidneys are subjected, their anterior surfaces are heaped up into what he terms "inclined planes." Whilst it must be admitted that under certain conditions these inclined planes are undoubtedly present, they cannot be regarded as being constant features of the kidneys, as these bodies are semi-solid organs which are, in all probability, perpetually undergoing in the living subject the most constant modifications in size and shape.

The Suprarenal Capsules.—The suprarenal capsules, although so closely connected with the kidneys, have nothing to do with the urinary functions. They belong to the ductless glands of the abdomen.

Each suprarenal capsule is a small, flattened, triangular body which surmounts the upper end of the kidney, and lies in the epigastric region on each side of the vertebral column.

There are two surfaces, *anterior* and *posterior*, and the hilum where the various vessels enter or leave the capsule is situated on the anterior surface.

The Anterior Surface of the Right Suprarenal Capsule.—The upper portion of the anterior surface of the right suprarenal capsule is in direct non-peritoneal contact with the lower and mesial angle of the bare area of the posterior surface of the liver.

The lower or basal portion is separated from the renal impression on the inferior surface of the right lobe of the liver by peritoneum.

The Anterior Surface of the Left Suprarenal Capsule.—The upper portion of the anterior surface of the left suprarenal

capsule is separated from the posterior surface of the stomach by peritoneum.

The lower and inner angle is in direct non-peritoneal contact with the posterior surface of the body of the pancreas, and with part of the splenic vein.

The Posterior Surfaces of both Suprarenal Capsules.—The posterior surfaces of both suprarenal capsules are in direct contact with the diaphragm.

Arterial Supply.—The arterial supply to the suprarenal capsules is altogether out of proportion to their small size. The arteries supplying the suprarenal capsules are three in number on each side as follows:—

1. The superior capsular artery, from the external division of the inferior phrenic artery.
2. The middle capsular artery, from the abdominal aorta.
3. The inferior capsular artery, from the renal artery.

Venous Return.—The venous return from the suprarenal capsules is by means of a single vein, on each side, termed the *capsular vein.* The right capsular vein terminates in the inferior vena cava; the left capsular vein terminates in the left renal vein.

The Ureters.—The ureters are the two tubes which conduct the urine from the kidneys into the bladder. Their length is about fifteen inches.

Each ureter commences in the pelvis of the kidney, and runs obliquely downwards and inwards to enter the cavity of the true pelvis, and then turns forwards and inwards to reach the base of the bladder.

Within the *abdominal cavity,* that is, from the kidney as far as the brim of the true pelvis, the ureters lie behind the peritoneum throughout, and rest upon the psoas muscle. In this course the right ureter descends close to the outer side of the inferior vena cava, and is crossed very obliquely from within outwards by the spermatic vessels. Lower down, the ureter passes in front of either the common or external iliac vessels, and behind the termination of the ileum.

The left ureter is not, of course, in relation to the inferior vena cava, but is crossed by the sigmoid flexure. With these two exceptions the relations of the left ureter are the same as those of the right side.

For the *pelvic* part of the course of the ureters, *see* page 159.

The Abdominal Aorta.—The abdominal aorta commences in the middle line of the body, at the lower border of the last dorsal vertebra, as the direct continuation of the descending thoracic aorta. It terminates opposite the middle of the body of the fourth lumbar vertebra, a little to the left of the middle line, by dividing into the two common iliac arteries.

The point of bifurcation may be indicated on the living subject by drawing a line between the highest points of the two iliac crests, and then taking a point on this line slightly to the left of the umbilicus. The abdominal aorta is about five inches long.

The immediate relations of the abdominal aorta are as follows:—

In Front, from above downwards.—The solar plexus and the peritoneum forming the posterior wall of the lesser sac.

The pancreas and the splenic vein.

The left renal vein.

The third part of the duodenum.

The aortic sympathetic plexus and the peritoneum of the greater sac.

Behind.—The anterior common ligament of the vertebræ.

The left lumbar veins.

The bodies and intervertebral discs of the lumbar vertebræ.

To the Right Side.—The inferior vena cava. This is in direct contact with the aorta at its lower part, but above it is separated from the aorta by the following structures:—

The right crus of the diaphragm.

The vena azygos major.

The thoracic duct.

To the Left Side, from above downwards.—The left crus of the diaphragm.

The left gangliated cord of the sympathetic.

Branches.—The branches of the abdominal aorta are

numerous and important; they may be classified as *visceral* and *parietal*, or as *paired* and *single*.

They are as follows, and in this order from above downwards:—

The inferior phrenic arteries.
The cœliac axis. (*See* page 100.)
The middle capsular arteries.
The superior mesenteric artery. (*See* page 103.)
The renal arteries.
The spermatic or ovarian arteries.
The inferior mesenteric artery. (*See* page 104.)
The common iliac arteries.
The middle sacral artery. (*See* page 175.)
The lumbar arteries.

The Inferior Phrenic Arteries.—These vessels arise inconstantly from the aorta as soon as it has entered the abdomen. They diverge from each other, and, passing across the crura of the diaphragm, incline upwards and outwards on its under surface.

The artery of the right side passes behind the inferior vena cava, that of the left side behind the œsophagus. Both vessels subsequently divide into two, and anastomose with the superior phrenic and musculo-phrenic arteries, with the lower intercostals, and with each other.

These vessels supply the diaphragm, and, in addition, the external division of each artery gives off a small branch to the suprarenal capsule, called the *superior capsular artery*.

The Middle Capsular Arteries.—These are two small vessels which arise from the aorta about the level of the superior mesenteric; they pass obliquely upwards and outwards in front of the crura of the diaphragm to the suprarenal bodies, where they anastomose with the superior and inferior capsular arteries.

The right middle capsular artery passes outwards behind the inferior vena cava.

The Renal Arteries.—These large vessels arise from the sides of the aorta, about half an inch below the superior mesenteric artery, that of the right side being usually lower and larger than that of the left side. Both vessels are overlapped by the corresponding renal vein, and both vessels give off an *inferior capsular artery.*

At the hilum of the kidney both vessels break up into four or five branches, which lie between the renal vein in front and the ureter behind.

The right renal artery, in consequence of the position of the aorta to the left of the middle line of the body, runs a somewhat longer course than the left renal artery, and in addition passes behind the inferior vena cava.

The Spermatic Arteries.—The spermatic arteries are two long slender vessels which arise from the front of the aorta just below the renal arteries.

Each artery passes downwards and outwards behind the peritoneum, and in front of the psoas muscle, the ureter, and the external iliac artery, to the internal abdominal ring, where it meets the other structures which form the spermatic cord, and so becomes a constituent of the spermatic cord.

The *right* spermatic artery also passes in front of the inferior vena cava.

There are three peculiarities to be noted in connection with the spermatic arteries—first, their small size in proportion to their length; second, they leave the cavity of the abdomen; third, they are straight in the abdomen and tortuous in the cord.

The *ovarian arteries* in the female pursue a similar course to the spermatic arteries, but do not leave the cavity of the abdomen. They reach the ovary by passing between the two layers of the broad ligament of the uterus.

The Common Iliac Arteries.—The common iliac arteries commence a little to the left side of the middle of the body of the fourth lumbar vertebra, by the bifurcation of the abdominal aorta. They pass downwards and outwards for two inches, and terminate opposite the lumbo-sacral articulation by dividing into external and internal iliac arteries.

Both common iliac arteries lie behind the peritoneum and the small intestine, and are crossed by the ureter near their termination, and also by filaments from the sympathetic.

In addition to these common relations there are certain special relations for each vessel. These are as follow:—

The *right common iliac artery* is separated from the fourth and fifth lumbar vertebræ by the two common iliac veins, and only touches the psoas muscle at its lower end.

The *left common iliac artery* is crossed in front by the superior hæmorrhoidal vessels. Posteriorly, it rests upon the bodies of the fourth and fifth lumbar vertebræ, close to the inner border of the psoas muscle.

Relation of the Left Common Iliac Artery to its Vein.—The left common iliac vein lies to the inner or right side of its artery.

Relations of the Right Common Iliac Artery to Veins.—There are three veins in relation to this artery, as follow:—

The *right common iliac vein* lies first behind and then to the outer or right side of its artery.

The *left common iliac vein* passes behind the commencement of the artery.

The *inferior vena cava* at its commencement lies to the outer or right side of the right common iliac artery at its upper part, being formed there by the two veins just mentioned, the right and left common iliac veins.

The Lumbar Arteries.—The lumbar arteries are five in number on each side; they arise from the back of the aorta, and very closely resemble the thoracic aortic intercostals.

The first pair of lumbar arteries pass upwards and outwards in front of the body of the last dorsal vertebra, the others in front of the bodies of the upper four lumbar vertebræ.

The lumbar arteries pass outwards behind the gangliated cord of the sympathetic and the psoas muscle; the three upper ones pass, in addition, behind the pillars of the diaphragm; whilst, lastly, the arteries of the right side run behind the inferior vena cava.

Opposite the intervals between the transverse processes of the lumbar vertebræ each lumbar artery divides into an abdominal and a dorsal branch.

The Abdominal Branch.—The abdominal branch from the first pair of lumbar arteries continues its outward direction in front of the quadratus lumborum muscle, accompanied by the last dorsal nerve; all the others pass behind this muscle. The vessels then pass between the muscles of the abdominal wall, and anastomose with the arteries of the abdominal wall.

The Dorsal Branch.—The dorsal branch passes backwards to the muscles of the back, and also gives off a *spinal branch* which enters the intervertebral foramen and supplies the spinal canal.

The Inferior Vena Cava.—The inferior vena cava commences on the right side of the fifth lumbar vertebra by the junction of the two common iliac veins. It terminates in the right auricle of the heart opposite the disc between the eighth and ninth dorsal vertebræ.

In this course the inferior vena cava ascends on the right side of the aorta, behind the peritoneum, the duodenum, the pancreas, and the lower end of the portal vein to the posterior surface of the liver, in which it becomes embedded. It then inclines forwards and to the right, to pass to its termination through the tendinous part of the diaphragm; that is, through the foramen quadratum, to the margins of which the wall of the vein is closely adherent.

Tributaries.—The tributaries of the inferior vena cava do not altogether correspond to the branches of the aorta, and they must in consequence be carefully noted. Its tributaries are:—

The common iliac veins.
The lumbar veins.
The right spermatic or ovarian vein.
The renal veins.
The right capsular vein.
The hepatic veins.
The inferior phrenic veins.

The Common Iliac Veins.—The two common iliac veins are formed on each side opposite the lumbo-sacral articulation by the junction of the external and internal iliac veins. They terminate on the right side of the fifth lumbar vertebra by uniting to form the inferior vena cava.

The *right common iliac vein* is rather shorter than the left, and passes almost vertically upwards. It is placed first behind and then to the outer or right side of its corresponding artery.

The *left common iliac vein* lies first to the inner or right

side of its companion artery, and then passes behind the commencement of the right common iliac artery.

Tributaries of the Common Iliac Veins.—Both common iliac veins receive, near their lower ends, the ilio-lumbar vein of their own side; whilst the *left common iliac vein* receives in addition the single venous trunk formed by the junction of the *two middle sacral veins*, and which correspond to the single unpaired middle sacral artery.

The Lumbar Veins.—The lumbar veins accompany the corresponding arteries. Those of the left side pass behind the aorta in order to reach the inferior vena cava.

The Right Spermatic or Ovarian Vein.—The right spermatic or ovarian vein terminates, at an acute angle, in the inferior vena cava.

On the left side, the *left spermatic or ovarian vein* terminates, at a right angle, in the *left renal vein.*

This difference in the mode and place of termination of the two spermatic veins in the male is stated to be one of several reasons why varicocele is commoner on the left side than on the right.

The Renal Veins.—The renal veins terminate, at a right angle, in the inferior vena cava.

The left renal vein is longer than the right, passes in front of the aorta, and receives two tributaries, the left spermatic or ovarian vein and the left capsular vein. The right renal vein receives no such tributaries.

Both renal veins tend to overlap their corresponding arteries.

The Right Capsular Vein.—The right capsular vein terminates in the inferior vena cava. The left capsular vein terminates in the left renal vein, or occasionally in the left inferior phrenic vein.

The Hepatic Veins.—The hepatic veins are situated in the substance of the liver, and have no existence outside that organ. They open directly into that part of the inferior vena cava which is embedded in the posterior surface of the liver. In order to demonstrate the open gaping mouths of the hepatic veins, it suffices to lay open the posterior wall of the hepatic portion of the inferior vena cava from behind.

The Inferior Phrenic Veins.—The inferior phrenic veins correspond to their arteries. They terminate in the inferior vena cava.

The left inferior phrenic vein occasionally receives the left capsular vein.

The External Iliac Arteries.—The external iliac arteries commence opposite the lumbo-sacral articulation by the division of the common iliac arteries. They pass downwards, forwards, and outwards for four inches, and terminate behind Poupart's ligament by becoming directly continuous with the femoral arteries.

The direction of the common and external iliac arteries may be indicated on the living subject by a line drawn from a point three-quarters of an inch below and to the left of the umbilicus to a point midway between the anterior superior iliac spine and the symphysis pubis.

Each external iliac artery is situated a little above the brim of the pelvis, against the inner border of the psoas muscle, but near its termination the artery comes to lie rather in front of that muscle, from which it is only separated by the fascia covering the psoas.

Superficial to each artery there is the peritoneum, with the ileum on the right side, and the sigmoid flexure on the left side; occasionally the ureter; whilst lastly, each vessel near its termination is crossed by the spermatic vessels, the deep circumflex iliac vein, and the genital branch of the genito-crural nerve.

The external iliac vein at its commencement lies to the inner side of, and on the same plane as the artery, but as the vein passes upwards it comes to lie behind the artery.

The crural branch of the genito-crural nerve is on the outer side of the external iliac artery.

Branches.—The branches of the external iliac artery are as follows:—

1. The deep epigastric artery. (*See* page 42.)
2. The deep circumflex iliac artery. (*See* page 44.)
3. Muscular branches to the psoas muscle.

The External Iliac Vein.—The external iliac vein commences behind Poupart's ligament as the direct continuation

of the femoral vein. It terminates opposite the lumbo-sacral articulation by uniting with the internal iliac vein to form the common iliac vein.

The external iliac vein lies at its origin on the same plane as, but internal to its companion artery. As the vein ascends it gradually passes behind the artery.

Tributaries.—The external iliac vein receives the *deep circumflex iliac* and *deep epigastric veins*, corresponding to the branches of the artery, and in addition a *pubic vein* which passes upwards from the obturator vein in the obturator foramen. The termination of the obturator vein is frequently represented by this pubic vein.

The Diaphragm. — This important muscle forms the division between the thorax and abdomen. It is the principal muscle of respiration.

By its external or circumferential border the diaphragm is attached to the chest wall; this circumferential border represents the *origin* of the muscle which is divided into three parts, as follows:—

1. A sternal origin, from the back of the ensiform cartilage.
2. A costal origin, from the deep surfaces of the cartilages of the six lower ribs.
3. A vertebral origin, by means of the crura and the arcuate ligaments.

1. The Sternal Origin.—This is by two narrow slips which arise from the ensiform cartilage. They are separated on each side from the adjacent costal origin by an interval, which transmits the superior epigastric branch of the internal mammary artery. At this point the thoracic and abdominal cavities are only separated by some loose connective tissue.

2. The Costal Origin.—This is by means of a series of muscular slips which arise from the deep surfaces of the costal cartilages of the six lower ribs, these slips interdigitating with those of the transversalis abdominis muscle.

3. The Vertebral Origin.—This origin takes place by means of the *crura* of the diaphragm and the *arcuate ligaments.*

(*a*) *The Crura of the Diaphragm.*—These are two tendinous and muscular slips which arise from the bodies, intervertebral discs, and anterior common ligament of the upper lumbar vertebræ.

The right crus extends as far down as the disc between the third and fourth lumbar vertebræ, that of the left side only to the disc between the second and third vertebræ.

The two crura are situated one on either side of the aorta; they are pointed and tendinous below, and broad and muscular above. The greater number of the muscular fibres in each pillar pass directly to their insertion in the central tendon, but the inner fibres of each pillar decussate in front of the opening for the aorta, and, passing onwards, almost surround the œsophageal aperture, for which aperture the two crura constitute a species of sphincter. The decussating fibres from the right crus are usually larger than those from the left, and pass in front of those from the left.

The left crus is usually the smaller of the two, and is situated rather farther from the middle line of the body than is the right crus, and at a slightly more posterior plane.

In front of the last dorsal vertebra the two crura are frequently connected together by a fibrous band which arches in front of the aorta. This, when present, is termed the *middle arcuate ligament.*

(*b*) *The Arcuate Ligaments.*—These are two in number on each side, and are termed respectively the internal and external arcuate ligaments.

The *internal arcuate ligament* arches over the psoas muscle, and is the stronger of the two arcuate ligaments. It extends from the body to the transverse process of the first lumbar vertebra. It is merely a specially thickened portion of the psoas fascia.

The *external arcuate ligament* arches over the quadratus lumborum muscle, and extends from the transverse process of the first lumbar vertebra to the last rib. It is merely a specially thickened portion of the fascia on the anterior surface of the quadratus lumborum muscle, that is, of the anterior lamella of the lumbar aponeurosis.

The gangliated cord of the sympathetic makes its appearance in the abdomen behind the internal arcuate ligament,

whilst the last dorsal nerve similarly makes its appearance behind the external arcuate ligament.

There is very frequently a small triangular interval left between the muscular fibres of the diaphragm arising from the external arcuate ligament and those arising from the last rib directly. When this interval is present, that part of the posterior surface of the kidney which is in contact with this part of the diaphragm is only separated from the pleura by loose areolar tissue.

Insertion of the Diaphragm.—From the foregoing extensive origin the various fibres arch upwards, to be inserted into the central trefoil tendon. This is a strong aponeurosis forming the central part of the diaphragm. It consists of three lobes, of which the right is the largest, the left the smallest.

The Diaphragmatic Foramina.—In the substance of the diaphragm there are several apertures or foramina for the transmission of certain structures from the thorax to the abdomen, and *vice versâ*. The larger apertures are three in number, and are named after the principal structure which they transmit, as follows:—

1. The aortic orifice.
2. The vena caval orifice.
3. The œsophageal orifice.

The Aortic Orifice.—The aortic orifice is situated between the two pillars of the diaphragm, opposite the twelfth dorsal vertebra.

It is bounded laterally and in front by the two crura of the diaphragm, and by the so-called *ligamentum arcuatum medium*, whilst there is also very frequently a fibrous band passing from the crura behind the aorta, so that in this way the aortic orifice is almost entirely surrounded by a fibrous ring.

The aortic orifice transmits, from right to left, the vena azygos major, the thoracic duct, and the aorta.

The Vena Caval Orifice, or the Foramen Quadratum.—This is situated in the central tendon of the diaphragm, at the junction of the right and left lobes respectively, about the level of the disc between the eighth and ninth dorsal vertebræ. It lies in front and slightly to the right of the aortic orifice.

The vena caval orifice is somewhat quadrilateral in outline, and its margins are adherent to the walls of the vena cava; as the orifice is situated in the tendinous portion of the diaphragm, contraction of the muscle will tend to dilate the orifice and so facilitate the return of the venous blood to the heart.

The vena caval orifice transmits the inferior vena cava and some minute filaments from the right phrenic nerve.

The Œsophageal Orifice.—This orifice lies between the two crura, and therefore in the muscular part of the diaphragm. It lies in front of and to the left of the aortic orifice, and also at a higher level, being situated opposite the tenth dorsal vertebra.

It transmits, from before backwards, the left vagus nerve, the œsophagus, and the right vagus nerve. Some small œsophageal branches from the coronary artery also pass through this orifice.

Effects of Contraction of the Diaphragm upon the three Chief Foramina.—Contraction of the diaphragm exercises very different effects upon the three chief diaphragmatic orifices.

Upon the aortic orifice there can be no effect produced, because that orifice is surrounded by a fibrous ring which lies altogether behind the diaphragm, consequently contraction of the diaphragm does not interfere with the arterial flow through the aorta.

Upon the vena caval orifice the effects produced are those of dilatation, with the facilitating of the venous return to the heart.

Upon the œsophageal orifice the diaphragm acts as a species of sphincter, inasmuch as that orifice is situated in the muscular portion of the muscle.

The Smaller Diaphragmatic Foramina.—In addition to the three chief apertures there are several smaller foramina in the substance of the diaphragm, as follows:—

(*a*) *The right crus of the diaphragm* is pierced by the three splanchnic nerves of the right side.

(*b*) *The left crus of the diaphragm* is pierced by the three splanchnic nerves of the left side, and by the vena azygos minor inferior.

(*c*) *The interval between the sternal and costal attachments* transmits, on each side, the superior epigastric branch of the internal mammary artery.

(*d*) *The costal attachments* of the diaphragm are pierced, on each side, opposite the eight or ninth ribs by the musculophrenic branch of the internal mammary artery.

Nerve Supply of the Diaphragm.—The diaphragm is supplied principally by the phrenic nerves from the fourth and fifth cervical nerves. It also receives filaments from the lower intercostals.

Relations of the Diaphragm.—The diaphragm is considerably arched, the right cupola rising higher than the left; to thoroughly appreciate the extent of this arching of the diaphragm, it is necessary to remember that on the right side the diaphragm rises nearly to a level with the nipple.

Its thoracic surface is covered by pleura, and is in contact with the lungs, pericardium, and heart.

The abdominal surface is lined in the greater part of its extent by peritoneum, and is in contact with the liver, stomach, pancreas, spleen, kidneys, and suprarenal capsules.

In consequence of the deficiencies in some parts of the diaphragm, there are certain places where the pleura and peritoneum are almost in direct contact. These places are principally to be found between the sternal and costal origins, and occasionally between the costal origin and that from the external arcuate ligament. At such places pleura and peritoneum are only separated by some loose connective tissue.

Action of the Diaphragm.—The diaphragm is an involuntary muscle of respiration; its contraction tends to lessen its arching, and thereby to increase the dimensions of the thoracic cavity.

The Receptaculum Chyli.—The receptaculum chyli is the dilated commencement of the thoracic duct. It is a narrow elongated sac about one inch long, situated opposite the second lumbar vertebra, between the right crus of the diaphragm and the aorta.

The receptaculum chyli is the common place of junction of the lymphatics from the lower limb with the trunks of the lacteal vessels, whilst above it becomes continuous with the thoracic duct which leaves the abdomen through the aortic orifice of the diaphragm.

To the right side of the receptaculum chyli is the vena azygos major; the whiteness of the walls of the former will serve to differentiate the two structures.

The Azygos Veins.—Two of the three azygos veins of the thorax commence in the abdomen. These are the vena azygos major and the vena azygos minor inferior.

The Vena Azygos Major.—The vena azygos major commences in the abdomen, generally as a continuation upwards of the ascending lumbar vein which connects together the lumbar veins. It may, however, commence less frequently in the inferior vena cava, or even in the right renal vein.

Having been formed in one of these three ways, the vena azygos major passes upwards and enters the thorax through the aortic orifice of the diaphragm.

The Vena Azygos Minor Inferior.—This commences on the left side in the same way as the vena azygos major, but enters the thorax through the left crus of the diaphragm.

The Fascia on the Posterior Abdominal Wall.—As has been stated (*see* page 38), the abdominal cavity is lined throughout by a sheet of fascia which receives different names in different portions of its extent. The names employed indicate the particular muscle with which the fascia is in contact. The various names given to the continuous abdominal fascial lining are as follows:—

1. The fascia transversalis.
2. The fascia iliaca.
3. The psoas fascia.

1. *The Fascia Transversalis.*—The fascia transversalis is that part of the abdominal fascial lining which is in contact with the deep surface of the transversalis abdominis muscle. It has been fully described with the anterior abdominal wall. (*See* page 38.)

2. *The Fascia Iliaca.*—The fascia iliaca is that part of the abdominal fascial lining which is in contact with the ilio-psoas muscle in the walls of the false pelvis. It is stronger and denser than the fascia transversalis.

The attachments of the fascia iliaca are important. They are as follow:—

Externally, the fascia iliaca is firmly tacked down to the iliac crest, and becomes continuous there with the fascia transversalis.

Internally, the fascia iliaca sweeps inwards, in front of the ilio-psoas muscle, to be attached to the brim of the true pelvis immediately internal to the psoas muscle. Near the sacral portion of the brim of the true pelvis the fascia iliaca becomes directly continuous with the parietal pelvic fascia.

Above, the fascia becomes directly continuous with the transversalis and psoas fasciæ.

Below, and external to the external iliac vessels, the fascia iliaca is attached to Poupart's ligament, and is here directly continuous with the fascia transversalis.

Immediately external to the external iliac vessels the fascia iliaca passes backwards from Poupart's ligament to the ilio-pectineal eminence, forming a well-marked band which is frequently referred to as the *ilio-pectineal fascia.*

Behind the external iliac vessels the fascia iliaca is prolonged downwards into the thigh behind the femoral vessels to form the posterior wall of the femoral sheath, and to become directly continuous with the *pectineal fascia* lying in front of the pectineus muscle, and so is established its continuity with the *pubic portion of the fascia lata* of the thigh.

In front of the fascia iliaca are the external iliac vessels and other abdominal structures, whilst *behind* it are the ilio-psoas muscle, anterior crural and external cutaneous nerves; lastly, the fascia iliaca is pierced from behind forwards by the genito-crural nerve, which thus comes to be an external relation of the external iliac artery.

3. *The Psoas Fascia.*—The psoas fascia is that part of the abdominal fascial lining which is in contact with the psoas muscle above the level of the iliac crest.

The attachments of the psoas fascia are as follows:—

Above, the psoas fascia becomes specially thickened and forms an arch termed the *ligamentum arcuatum internum.* (*See* page 132.)

Below, the psoas fascia becomes directly continuous with the fascia iliaca.

Internally, the psoas fascia is attached to the bodies of the lumbar vertebræ by a series of fibrous arches which bridge over the lumbar arteries.

Externally, the psoas fascia becomes directly continuous with the fascia transversalis immediately in front of the anterior lamella of the lumbar aponeurosis and the quadratus lumborum muscle.

The Muscles on the Posterior Abdominal Wall.—The muscles on the posterior abdominal wall are usually three in number—

The psoas magnus muscle.
The iliacus muscle.
The quadratus lumborum muscle.

There is occasionally a fourth muscle present, the small and inconstant *psoas parvus.*

The Psoas Magnus Muscle.—This is an elongated muscle which lies on the sides of the lumbar vertebræ and extends downwards along the brim of the true pelvis to the small trochanter of the femur.

Origin.—The psoas magnus has a triple origin as follows:—

1. By five fleshy slips from the lower borders and anterior surfaces of the transverse processes of the five lumbar vertebræ, near their roots.
2. By five slips, each of which arises from the intervertebral discs and adjacent margins of the bodies of the lumbar vertebræ; the highest slip is attached to the body of the last dorsal vertebra.
3. From the five tendinous arches which are formed by the psoas fascia, and which arch over the five lumbar arteries.

Insertion.—As the muscle passes downwards along the brim of the true pelvis it gradually becomes narrower. A tendon then appears at the outer border of the muscle, which gives insertion in part to the adjacent iliacus muscle, after which the conjoined ilio-psoas tendon passes downwards behind Poupart's ligament to be inserted—as regards the

psoas—by means of a broad tendon into the small trochanter of the femur.

Nerve Supply.—The psoas is supplied by the second and third lumbar nerves, where they lie in the muscle substance.

Action.—The combined ilio-psoas muscle is a powerful flexor of the hip-joint. It is the great antagonistic of the gluteus maximus muscle.

Relations. — The relations of the psoas muscle are numerous and important. As regards these relations, the *abdominal* portion of the muscle may be regarded as presenting for examination an anterior and a posterior surface, and an internal and an external border.

(*a*) *The anterior surfaec* of the psoas is in contact with the psoas fascia above the level of the iliac crest, and with the fascia iliaca below that level. The upper portion of the psoas fascia is specially thickened to form the *ligamentum arcuatum internum.* The upper end of the psoas muscle lies behind this ligament and behind that part of the diaphragm which arises from it.

The genito-crural nerve pierces the psoas muscle and runs down its anterior surface between the muscle and its fascial covering. This nerve is sometimes represented by two or even three filaments.

The fascial coverings of the psoas separate the anterior surface of the *right* psoas from the right kidney, the renal vessels and the ureter, the ascending colon, the cæcum and terminal portion of the ileum, and the spermatic vessels.

The anterior surface of the *left* psoas muscle is similarly separated from the left kidney, the renal vessels and the ureter, and the spermatic vessels.

(*b*) *The posterior surface* of the psoas muscle is in apposition with the lumbar vertebræ, with the anterior lamella of the lumbar aponeurosis, with the brim of the pelvis and with the iliacus muscle.

(*c*) *The internal border of the psoas muscle* is in contact with the bodies of the lumbar vertebræ and the gangliated cord of the sympathetic, and along the brim of the pelvis, with the external iliac artery. It also forms a guide to the obturator nerve.

(*d*) *The outer border of the psoas muscle* overlaps the anterior lamella of the lumbar aponeurosis and the quadratus lumborum muscle, and, lower down, the iliacus muscle.

This border forms an important guide to some of the branches of the lumbar plexus. The nerves which make their appearance at the outer border of the psoas muscle are, in order from above downwards:—

The *ilio-inguinal* and *ilio-hypogastric* nerves at the upper part of the outer border of the muscle.

The *external cutaneous* nerve lower down.

The *anterior crural* nerve, a large nerve, runs down the lower part of the outer border of the psoas, between it and the iliacus.

(*e*) *Embedded in the substance of the psoas* is the lumbar plexus.

The Iliacus Muscle.—The iliacus muscle occupies the iliac fossa in the wall of the false pelvis. It passes behind Poupart's ligament, with the psoas muscle as the combined ilio-psoas, to the small trochanter of the femur.

Origin.—From the upper half of the iliac fossa of the os innominatum, from the ala of the sacrum, and from the anterior sacro-iliac ligament.

Insertion.—The muscular fibres pass downwards and inwards, and, converging as they descend, are inserted into the tendon of the psoas and into the shaft of the femur, in front of and below the small trochanter.

Nerve Supply.—The anterior crural nerve.

Action.—The same as the psoas magnus.

The Quadratus Lumborum Muscle.—This is a quadrilateral muscle lying behind and external to the upper part of the psoas magnus muscle, and stretching between the last rib and the posterior part of the iliac crest.

Origin.—From the ilio-lumbar ligament, and from two inches of the iliac crest behind and external to that ligament.

The most internal fibres also arise from the transverse processes of the lower two, three, or four lumbar vertebræ.

Insertion.—The muscular fibres pass upwards to be in-

serted into the inner half of the last rib, behind the *external arcuate ligament*; and also into the tips of the transverse processes of the upper four lumbar vertebræ.

Nerve Supply.—The last dorsal and first two lumbar nerves.

Action.—A lateral flexor of the spine.

Relations.—The quadratus lumborum lies in the anterior of the two compartments formed by the lumbar aponeurosis (*see* page 36), that is, between the anterior and middle lamellæ of the lumbar aponeurosis.

The anterior lamella of the lumbar aponeurosis, which lies immediately in front of the quadratus lumborum muscle, is sometimes unfortunately termed the *quadratus lumborum fascia*, and thereby confused with the general fascial lining of the abdominal cavity. The two structures have nothing in common.

The anterior lamella of the lumbar aponeurosis forms part of the origin of the transversalis abdominis muscle. It lies in front of the quadratus lumborum muscle, and is attached internally to the bodies of the lumbar vertebræ close to the pedicles. Externally, it fuses with the middle lamella. Above, it becomes especially thick and so forms the *ligamentum arcuatum externum.* Below, it is attached to the ilio-lumbar ligament.

The external border of the quadratus lumborum muscle forms an excellent surgical guide to the colon.

The Psoas Parvus Muscle.—This small muscle is only very occasionally present. It lies in front of the psoas magnus muscle, and extends from the bodies of the twelfth dorsal and first lumbar vertebræ to the ilio-pectineal line and eminence.

The Sympathetic System in the Abdomen.—The sympathetic system within the abdominal cavity, that is, from the diaphragm to the pelvic brim, consists of the following parts:—

Two gangliated cords.
The solar or epigastric plexus.
Numerous subsidiary plexuses, offsets from the solar plexus, which accompany the abdominal arteries.

The Gangliated Cords.—The gangliated cords of the sympathetic enter the abdomen from the thorax usually behind the internal arcuate ligaments, or more occasionally by piercing the crura of the diaphragm. They lie on the front of the bodies of the lumbar vertebræ, along the inner margin of the psoas muscle.

The right cord is partly concealed by the inferior vena cava, the left cord by the aorta. They pass downwards behind the renal arteries, and enter the pelvis behind the common iliac arteries. On each cord there are usually four ganglia.

Branches.—From each ganglion are given off *external* and *internal* branches.

A. The external branches are usually two in number from each of the four ganglia. They connect the ganglia with the anterior primary divisions of the lumbar nerves, and accompany the lumbar arteries.

B. The internal branches are chiefly distributed to the aortic plexus, but some accompany the common iliac artery to join the hypogastric plexus in the pelvis.

The Solar or Epigastric Plexus.—This is one of the three great *prevertebral plexuses* found in connection with the sympathetic system throughout the body.

These three plexuses are as follows:—

Thorax.—The cardiac plexus.
Abdomen.—The solar or epigastric plexus.
Pelvis.—The hypogastric plexus.

The solar plexus, the largest of the three prevertebral plexuses, is situated at the upper part of the abdomen, behind the stomach, and in front of the aorta and the pillars of the diaphragm.

It occupies the interval between the suprarenal bodies, surrounds the cœliac and superior mesenteric arteries at their origins, and extends downwards behind the pancreas.

It is composed of the following parts:—

Branches from the gangliated cords.
Numerous ganglia, of which the largest are the semilunar ganglia.
Branches from the pneumogastric nerves.
The large and small splanchnic nerves.

The Semilunar Ganglia.—These are the largest of the numerous ganglia found in the plexus. They are two

almond-shaped bodies, occupying the upper and outer part of the plexus. They are situated close to the suprarenal bodies, on either side of the cœliac axis. The upper end of each ganglion is joined by the great splanchnic nerve, whilst its lower end is joined by the small splanchnic nerve.

The Large and Small Splanchnic Nerves.—These, as has been stated, join the upper and lower parts respectively of the semilunar ganglia.

Branches of the Solar or Epigastric Plexus.—These are very numerous. Briefly, it may be stated that the branches from the solar or epigastric plexus accompany the various abdominal vessels, and give off secondary branches, as do the various arteries themselves. The principal branches from the solar plexus are :—

The aortic plexus.
The diaphragmatic or phrenic plexus.
The cœliac plexus.
The suprarenal plexus.
The superior mesenteric plexus.
The renal plexus.
The spermatic plexus.
The inferior mesenteric plexus.

The Lumbar Nerves.—The anterior primary divisions of the five lumbar nerves are embedded in the substance of the psoas magnus muscle. The nerves successively increase in size from above downwards, and are connected to the gangliated cord of the sympathetic.

The anterior primary divisions of the first three, and part of that of the fourth lumbar nerves, take part in the formation of the lumbar plexus.

The remaining portion of the anterior primary division of the fourth lumbar nerve unites with that of the fifth lumbar nerve to form the *lumbo-sacral cord*, which descends to take part in the formation of the sacral plexus.

The Lumbar Plexus.—The lumbar plexus, one of the simplest of the plexuses, lies in the substance of the psoas muscle, and in front of the transverse processes of the lumbar vertebræ.

It is formed in the following manner:—

By a small part of the anterior primary division of the twelfth dorsal nerve.

By the anterior primary divisions of the first three lumbar nerves.

By a small part of the anterior primary division of the fourth lumbar nerve.

The nerves which enter into the formation of the plexus do not form an interlacement, as in the case of the brachial plexus, but merely unite and give off their branches.

Branches.—The branches from the lumbar plexus are destined for the supply of the lower part of the abdominal wall; and, secondly, for the supply of the anterior and inner parts of the thigh.

The abdominal branches are:—

The ilio-hypogastric nerve.
The ilio-inguinal nerve.
The genital branch of the genito-crural nerve.

The branches for the thigh are:—

The crural branch of the genito-crural nerve.
The external cutaneous nerve.
The obturator nerve.
The anterior crural nerve.

These various nerves must be recognised both from their relations to the psoas muscle, and also from their origins from the lumbar nerves themselves.

Their *relations to the psoas muscle* are as follows:—

The *ilio-inguinal* and *ilio-hypogastric* nerves make their appearance close together at the upper part of the outer border of the psoas muscle. To distinguish between the two, it must be remembered that the ilio-hypogastric nerve is the higher and larger of the two nerves.

It is still more important to differentiate between these two nerves and the last dorsal nerve which lies immediately above them. To do this the student must particularly remember that the *last dorsal* is the largest and the flattest of the three nerves. It runs immediately below the last rib, and it should be seen making its appearance from behind the *ligamentum arcuatum externum*. If these points are carefully

noted there should be no difficulty in differentiating between the last dorsal nerve and the first two branches from the lumbar plexus, namely, the ilio-inguinal and ilio-hypogastric nerves.

The *external cutaneous* nerve emerges about the middle, or a little lower, of the outer border of the psoas muscle.

The *anterior crural* nerve emerges from the lower part of the outer border of the psoas muscle. It may also be recognised by its large size, as it is the largest nerve given off by the lumbar plexus.

The *obturator* nerve runs downwards along the inner border of the psoas muscle.

The *genito-crural* nerve pierces the substance of the muscle, sometimes in two, or even three parts.

When *the psoas muscle has been removed*, the branches from the lumbar plexus must be recognised from a knowledge of the various nerves from which they arise. Their mode of origin is as follows:—

The *ilio-inguinal* and *ilio-hypogastric* nerves arise from the first nerve.

The *genito-crural* nerve from the first and second nerves.

The *external cutaneous* nerve from the second and third nerves.

The *anterior crural* and *obturator* nerves from the second, third, and fourth nerves.

The recognition of these various nerves, after removal of the psoas muscle, is greatly facilitated by counting the anterior primary divisions of the lumbar nerves themselves from below upwards, commencing with the fifth lumbar nerve, which may be recognised by its large size and by its relation to the lumbo-sacral cord. Once this fifth lumbar nerve has been eliminated the other nerves and their branches are easily recognised.

The Ilio-Hypogastric Nerve.—The ilio-hypogastric nerve is derived from the anterior primary division of the first lumbar nerve in common with the ilio-inguinal nerve.

It makes its appearance at the upper part of the outer border of the psoas muscle, from whence it runs outwards in front of the quadratus lumborum muscle, and, piercing the transversalis abdominis muscle near the iliac crest, leaves the abdominal cavity. (*See* page 34.)

The Ilio-Inguinal Nerve.—The ilio-inguinal nerve, smaller than the ilio-hypogastric, lies immediately below that nerve and pursues an almost similar course. It passes obliquely downwards and outwards in front of the quadratus lumborum muscle and the upper part of the iliacus, and leaves the abdominal cavity by piercing the transversalis abdominis muscle just in front of the ilio-hypogastric nerve. (*See* page 34.)

The Genito-Crural Nerve.—The genito-crural nerve is derived from the anterior primary divisions of the first and second lumbar nerves. It passes forwards through the psoas muscle, and divides, either in the substance of the muscle or in front of it, into its two terminal branches—genital and crural.

A. The genital branch passes downwards and inwards in front of the psoas muscle, and, after piercing the fascia iliaca, crosses the external iliac artery and so reaches the internal abdominal ring, where it becomes a constituent of the spermatic cord.

B. The crural branch pierces the fascia iliaca in front of the lower part of the psoas muscle, and so comes to lie to the outer side of the external iliac artery. It accompanies that vessel behind Poupart's ligament into the thigh.

The External Cutaneous Nerve.—The external cutaneous nerve is derived from the anterior primary divisions of the second and third lumbar nerves. It makes its appearance rather below the middle of the outer border of the psoas magnus, and descends obliquely across the iliacus towards the anterior superior iliac spine. Just internal to that spine it enters the thigh behind Poupart's ligament.

The Anterior Crural Nerve.—The anterior crural nerve—the largest branch given off by the lumbar plexus—is derived from the anterior primary divisions of the second, third, and fourth lumbar nerves. It makes its appearance at the lower part of the outer border of the psoas, between that muscle and the iliacus, and descends into the thigh behind Poupart's ligament

The Obturator Nerve.—The obturator nerve, like the anterior crural, is derived from the anterior primary divisions of the second, third, and fourth lumbar nerves. It makes its appearance at the inner border of the psoas, and runs downwards along the lateral wall of the true pelvis, just below the pelvic brim to the upper part of the obturator foramen, through which it passes to the adductor region of the thigh.

The Lumbo-Sacral Cord.—The lumbo-sacral cord is formed by the junction of the descending part of the anterior primary division of the fourth with the whole of that of the fifth lumbar nerve. It descends into the pelvis, in front of the base of the sacrum, to take part in the formation of the sacral plexus.

The Last Dorsal Nerve.—The anterior primary division of the last dorsal nerve enters the abdominal cavity behind the external arcuate ligament of the diaphragm.

It lies immediately below the last rib and passes outwards in front of the quadratus lumborum muscle accompanied by the abdominal branch of the first lumbar artery, as far as the outer border of the quadratus lumborum, where it pierces the lumbar aponeurosis, and so leaves the abdominal cavity. (*See* page 34.)

The Accessory Obturator Nerve.—This small nerve is present in about one out of every four subjects. It arises from the third and fourth lumbar nerves, between the roots of the obturator and anterior crural nerves. It descends along the inner border of the psoas muscle, crosses the ramus of the pubis, and, passing behind the pectineus muscle, divides into three branches. Of these three branches, one joins the superficial division of the obturator nerve itself, a second ends in the substance of the pectineus muscle, and the third passes to the hip-joint.

IV. THE MALE PELVIS

Definition. — The pelvis is that part of the general abdominal cavity which lies below and behind the brim of the true pelvis.

Boundaries.—In studying the boundaries of the pelvis it is most important to do so with the pelvis in the position which it assumes when the body is in the erect attitude.

All the terms hereafter employed in the description of the pelvic boundaries are strictly referable to the erect attitude.

The true pelvis possesses a pelvic brim, or inlet; a pelvic cavity; and an outlet—the anatomical perineum.

The *pelvic brim or inlet* is formed by a plane passing through the sacral promontory, the ilio-pectineal lines, and the anterior border of the symphysis pubis. The expanded part of the innominate bones above this brim is sometimes termed the *false pelvis* but belongs to the general abdominal cavity.

The *pelvic cavity* contains the more important parts of the genito-urinary apparatus, the rectum, and other important structures.

The *pelvic outlet,* or the postero-inferior circumference of the pelvis, constitutes the anatomical perineum.

Position of the Pelvis.—In the erect position of the body the pelvis is oriented in such a manner that its brim forms, with the horizon, an angle of from 50° to 60°. To appreciate this angle, place an articulated pelvis in such a manner that the tip of the coccyx will be almost on the same level as the highest part of the symphysis pubis.

The *axis of the pelvis* is the name given to a line drawn at right angles to the planes of the brim, cavity, and outlet; this line passes through their central points, and is almost coincident with the curve of the sacrum and coccyx.

Wall of the Pelvis.—The wall of the pelvis, in the recent condition, consists of three layers, the component parts of each layer lying in the same morphological plane. These three layers are as follows:—

1. *An Osseous, Ligamentous, and Membranous Layer.*—This layer is bounded, below, by the pubic portion of the innominate bones and the triangular ligament; on either side, by the innominate bones and the obturator membrane; above, by the sacrum and coccyx and the sacro-sciatic ligaments.

2. *A Muscular Layer.*—This layer comprises, below, the compressor urethræ muscle, on either side the obturator internus muscles, and, above, the two pyriformis muscles.

3. *A Fascial Layer.* — This layer is formed by the fascia lining the interior of the pelvis, the *parietal pelvic fascia.*

Connections of the Pelvic Cavity.—*Above,* the pelvic cavity is freely continuous with the general abdominal cavity; *below and behind,* it is completely shut off from the perineum by the pelvic diaphragm, in just the same manner as the abdominal cavity is shut off from the thorax by the diaphragm itself.

The so-called *pelvic diaphragm* is constituted by the levatores ani and coccygei muscles, and is the only movable wall of the pelvis. It is pierced, just as is the diaphragm proper, by certain structures, which in this instance are passing out of the pelvis, such as the rectum, urethra, or the vagina.

The Pelvic Fascia.—The pelvic fascia consists of two distinct parts, a *parietal* layer lining the wall of the pelvis and constituting the third stratum in the pelvic wall itself, and a *visceral* layer which stretches across the pelvic cavity and assists in separating that cavity from the perineum. This visceral part of the pelvic fascia is usually termed the *recto-vesical* fascia.

The Parietal Pelvic Fascia—The parietal pelvic fascia is a thin membrane which lines the interior of the pelvis and is in contact with the deep surfaces of the muscles bounding that cavity.

Certain portions of this fascia receive special names: that portion of the parietal pelvic fascia which is in contact with the pyriformis muscle is termed the *pyriformis* fascia; that in contact with the obturator internus muscle, the *obturator* fascia; and in the region of the pubic arch, that portion of the parietal pelvic fascia which is in apposition with the triangular ligament, constitutes the second layer of the deep perineal fascia, and is hence sometimes termed the *superior or the deep layer of the triangular ligament.*

Attachments.—The parietal pelvic fascia is attached *above* to the base of the sacrum, and to about one inch of the ilio-pectineal line, and then along a line which gradually sinks from this point to the posterior border of the symphysis pubis below. In consequence of this last attachment it follows that the deep surface of the symphysis pubis is devoid of a fascial lining, whilst in the region of the obturator foramen the fascia joins the upper edge of the obturator membrane, forming an arch above the upper border of the obturator internus muscle, and so permitting the obturator vessels to leave the pelvic cavity without piercing the parietal pelvic fascia.

Below, or at the outlet of the pelvis, the parietal pelvic fascia is attached to the coccyx, the great sacro-sciatic ligament, the ischial tuberosity, and to the base of the triangular ligament.

That portion of the parietal pelvic fascia which is known as the pyriformis fascia is a thin and unimportant layer lying immediately below the pyriformis muscle and the nerves of the sacral plexus. It is continued on to the sacrum from the obturator fascia, and is pierced by those branches of the internal iliac artery which leave the pelvis through the great sacro-sciatic foramen—the gluteal, sciatic, and internal pudic arteries.

That portion of the parietal pelvic fascia which is known as the obturator fascia is a much more distinct portion than the pyriformis fascia. It clothes the deep surface of the obturator internus muscle, and, as has already been seen in the dissection of the perineum, forms one of the boundaries of the outer wall of the ischio-rectal fossa.

That portion of the parietal pelvic fascia which is in apposition with the triangular ligament constitutes the remaining part of the deep perineal fascia. This particular portion of the parietal pelvic fascia is sometimes known as the *superior or deep layer of the triangular ligament.*

It is attached to the posterior border of the symphysis pubis in front, the base of the triangular ligament behind, and on either side to the ischio-pubic rami, thus forming the upper or deep boundary of the deep perineal pouch. In this region the parietal pelvic fascia consists of two lateral halves, which,

passing inwards from their ischio-pubic attachments just given, reach the middle line, and then sweep upwards to become continuous with the sheath of the prostate gland, derived from the recto-vesical or visceral layer of the pelvic fascia.

The last point to be noted in connection with the parietal pelvic fascia is the relative position of the pelvic vessels and nerves to the fascia. The nerves lie *external* to the fascia, and therefore do not require to pierce it in order to leave the pelvic cavity; the vessels, on the other hand, lie *internal* to the fascia, and must, in consequence, pierce the parietal pelvic fascia before escaping from the pelvis. The obturator artery is the only exception to this rule, and this, as has been pointed out, leaves the pelvis above the upper limit of the attachment of the parietal pelvic fascia. As the various vessels pierce the fascia they receive prolongations from it, and it is through these apertures that some of those very rare forms of hernia, such as sciatic hernia, leave the abdominal cavity.

The Recto-Vesical Fascia.—The visceral layer of the pelvic fascia, or the recto-vesical fascia, crosses the cavity of the true pelvis, dividing it into two chambers, one of which constitutes the pelvis proper, whilst the other is the anatomical perineum.

In this way the recto-vesical fascia forms a partition across the pelvic cavity which is perforated by the urethra and rectum, both of which the fascia supports. It is in contact with the pelvic surfaces of the levatores ani and coccygei muscles, and is therefore concave above and convex below.

The recto-vesical fascia, if seen from above and in front, would present more or less a circular appearance, with two apertures for the passage of the urethra and rectum. The circumference or external border of the recto-vesical fascia is attached to the os pubis and the parietal pelvic fascia as follows:—

Below, the recto-vesical fascia is attached to the deep surface of the os pubis above and in front of the parietal pelvic fascia; consequently, on this surface of the os pubis there will be a small bony area at the lower and posterior part of the symphysis pubis between the recto-vesical fascia and the parietal pelvic fascia, which is devoid of fascial covering; it gives origin to some of the fibres of the levator ani muscle.

Laterally, the circumference of the recto-vesical fascia springs from the parietal pelvic fascia, along a curved line which runs from the pubic attachment across the obturator foramen to the ischial spine; whilst *above*, the line of attachment is continued along the lower part of that portion of the parietal pelvic fascia which is known as the pyriformis fascia. The inferior two-thirds of this circumferential attachment of visceral fascia to parietal fascia, that is, from the ischial spine to the symphysis pubis, is known as the "white line."

From this circumferential attachment the recto-vesical fascia passes downwards and inwards in contact with the upper surfaces of the levatores ani muscles until it reaches the interval between the bladder and the rectum, where it gives off partial coverings to these viscera.

One layer partially invests the bladder, constituting the so-called *vesical* portion of the fascia.

A second layer passes between the bladder and rectum, constituting the so-called *recto-vesical* portion of the fascia; whilst a third layer partially invests the rectum, forming the *rectal* portion of the fascia.

At certain places the recto-vesical fascia is specially thickened, forming what are known as the *true ligaments of the bladder*. These are described with that viscus. (*See* page 157.)

The *anal fascia* is a special layer of fascia covering the perineal surface of each levator ani muscle; hence this fascia constitutes one of the boundaries of the ischio-rectal fossa.

The Peritoneum.—The peritoneum in the pelvis is not so closely adherent to the viscera as in the abdomen. After completely surrounding the first part of the rectum, and forming its meso-rectum, the peritoneum gradually leaves the rectum, first at its sides and afterwards in front, and is then reflected upwards on the base, and then forwards over the superior or abdominal surface of the bladder, on to the anterior abdominal wall. Between the bladder and the

rectum there is thus formed, by the peritoneum, a distinct pouch, termed the *recto-vesical pouch.*

The Recto-Vesical Pouch.—The recto-vesical pouch is the pouch formed by the reflection of the peritoneum from the rectum to the base of the bladder.

The most dependent part of the pouch corresponds, usually, to a line drawn between the middle of the seminal vesicles, that is, to the base of the external trigone of the bladder. This is usually situated about one inch above the base of the prostate and three inches above the anus, but is subject to variation. The depth of the pouch varies considerably with the amount of distension, or otherwise, of the bladder and rectum.

In the female the recto-vesical pouch is subdivided, by means of the upward projection of the uterus, into two pouches, an anterior or *utero-vesical pouch*; and a posterior larger, and more important pouch, the *utero-rectal pouch, or the pouch of Douglas.*

On either side the recto-vesical pouch is bounded by a double fold of peritoneum, the *posterior false ligaments* of the bladder, which are raised up by the obliterated hypogastric arteries passing from the back to the front of the pelvis. These, as well as the other peritoneal reflections from the bladder—the false ligaments of the bladder—are described with that viscus.

The Bladder.—The bladder is a hollow musculo-membranous viscus for the reception of urine. In the adult it is situated in the pelvis, immediately above and behind the pubis; in the fœtus and the child, however, the bladder is much more an abdominal than a pelvic organ.

Shape.—The shape of the bladder, as well as its size, position, and relations, vary according to the degree of distension, or otherwise. It is therefore necessary to examine an empty systolic bladder, an empty diastolic bladder, a moderately distended bladder, and an excessively distended bladder.

An empty systolic bladder, that is, an empty bladder with its muscular walls in a state of contraction, is somewhat globular with greatly thickened muscular walls and its upper surface rounded and convex, whilst the mucous membrane is thrown into innumerable folds.

An empty diastolic bladder, that is, an empty bladder with its muscular walls in a state of relaxation, is Y-shaped, the stem of the Y being formed by the first part of the urethra, and the two limbs by the bladder itself. The anterior limb is the longer of the two, and passes upwards and forwards, whilst the posterior limb passes upwards and backwards. Such a bladder possesses three surfaces—superior, anterior, and posterior.

A moderately distended bladder will be fully described immediately.

An excessively distended bladder is ovoid or egg-shaped, with the long axis passing upwards and forwards. In such a case the bladder is no longer confined to the pelvis, but enters the abdomen, its apex reaching as high as, or even higher than, the umbilicus.

Dimensions.—The dimensions of the bladder vary more than those of any other dilatable viscus. When moderately distended, the average capacity of the bladder is about one pint, but it is capable of holding considerably more than this.

Description.—The moderately distended bladder, to which the following description applies, is described as possessing a base or fundus, an apex or summit, a superior or abdominal surface, an antero-inferior or pubic surface, and a neck.

The Base or Fundus.—The base of the bladder, its widest part, looks downwards and backwards.

It is in contact posteriorly with the second part of the rectum; in the upper part the two viscera are separated from one another by the peritoneum of the recto-vesical pouch, which intervenes between the bladder and the rectum. Below the line of reflection of peritoneum that portion of the base of the bladder which is in contact with the rectum is triangular in outline, and is known as the *external trigone* of the bladder; this has very definite boundaries, as follows:—

The base of the external trigone is uppermost, and is formed by the most dependent part of the recto-vesical pouch. On either side, the external trigone is bounded by the vasa

deferentia and vesiculæ seminales, whilst the apex of the triangle is below at the base of the prostate gland. Intervening between the external trigone and the second part of the rectum there is the recto-vesical layer of the pelvic fascia. The base of the bladder, though very intimately associated with the second part of the rectum, is therefore separated from it, above, by the peritoneum of the recto-vesical pouch; and below, by the recto-vesical layer of the pelvic fascia, and by the vasa deferentia and seminal vesicles.

The very intimate relations of the bladder and rectum explain the ease with which the bladder can be examined by means of a rectal examination, and how it is possible to displace the bladder upwards and forwards, in certain pelvic operations, by means of a Petersen's air-bag introduced into the rectal ampulla.

Opening into the upper part of the base of the bladder are the ureters.

The Apex or Summit.—The apex or summit of the bladder, its most movable part, looks upwards and forwards. When the bladder is empty, or only very partially filled, the apex lies above and behind the symphysis pubis, but as the bladder distends the apex gradually rises behind the anterior abdominal wall.

Passing from the apex of the bladder to the umbilicus, there is a narrow tapering median cord, the *urachus*. This structure, which in the adult is composed of fibrous tissue, with muscular prolongations on it from the bladder, is the remains of the allantois—a fœtal structure.

On either side of the urachus the obliterated hypogastric arteries pass forwards and upwards from the apex of the bladder .to the umbilicus.

The Superior or Abdominal Surface.—The superior or abdominal surface of the bladder is covered by peritoneum throughout. The abdominal surface of the bladder is free, and is in contact with either the sigmoid flexure or the loops of the jejuno-ileum, more frequently the latter.

The Antero-Inferior or Pubic Surface.—This surface, which is entirely destitute of peritoneal covering, extends from the apex of the bladder above, to the point at which the anterior true ligaments join the bladder below. It is in contact with the retro-pubic pad of fat, which separates it from the symphysis and body of the pubis; as the bladder distends, this surface gradually passes upwards, and comes into contact with the anterior abdominal wall, the peritoneum on that wall being gradually lifted off by the ascending bladder; hence, in cases of retention of urine with over-distended bladder, that organ can be tapped suprapubically without wounding the peritoneum.

The Neck of the Bladder.—The neck of the bladder is that portion of it which joins the urethra. It lies immediately in front of the base, between it and the antero-inferior surface, and is surrounded by the base of the prostate. With the body in the erect attitude, the vesical orifice of the urethra is usually the lowest part of the bladder. It is situated about one inch behind the middle of the pubic symphysis.

Passing forwards on each side of the bladder is the obliterated hypogastric artery, which runs to the apex of the bladder and thence on to the umbilicus. As these vessels pass forwards alongside the bladder they lift off the peritoneum from its lateral margins to form the lateral false ligaments of the bladder. The vas deferens passes to the inner side of the obliterated hypogastric artery near its posterior end, on each side, to reach the base of the bladder.

Method of Fixation of the Bladder.—The bladder, though capable of great enlargement, is very constant in its position, as it is maintained *in situ* in a variety of ways.

From above it is, as it were, suspended by the urachus and the obliterated hypogastric arteries, passing from the umbilicus to the apex of the viscus.

In front it is fixed to the pubis by means of the anterior true ligaments, and laterally it is further fixed by its lateral true ligaments.

On all sides the peritoneal reflections from the bladder to the pelvic wall tend, though to a much less degree, to maintain the viscus in position.

Whilst lastly, below, its continuity with the urethra assists in this fixation. From these numerous methods of

fixation it will readily be understood that herniation of the bladder is extremely rare.

Ligaments of the Bladder.—The ligaments of the bladder are nine in number, four of which, formed by the visceral layer of the pelvic fascia, are termed *true ligaments,* whilst the remaining five are peritoneal reflections and are termed *false ligaments.*

The True Ligaments of the Bladder.—These are merely specially thickened and specially named portions of the visceral layer of the pelvic fascia; they are four in number, two anterior and two lateral.

The Anterior True Ligaments, or the Pubo-Prostatic Ligaments, are two narrow strong bands of visceral pelvic fascia, situated one on either side of the middle line of the body, and containing involuntary muscular fibres. They are attached *anteriorly* to the deep surface of the body of the os pubis, just above and in front of the attachments of the levatores ani muscles, from whence they pass backwards to the junction of the base of the prostate gland and neck of the bladder. Between the two ligaments there is a distinct depression containing some areolar tissue.

The term "pubo-prostatic," as applied to these ligaments, is obviously inapplicable in the female.

The Lateral True Ligaments are composed of that portion of the visceral layer of the pelvic fascia which passes inwards from the "white line" to the junction of the bladder and prostate.

The False Ligaments of the Bladder.—These are five in number, and are formed by the various peritoneal reflections from the bladder to the pelvic or abdominal walls.

The Superior False Ligament, a single ligament, is that portion of peritoneum which is raised up from the anterior abdominal wall by the passage of the urachus and the two obliterated hypogastric arteries from the apex of the bladder to the umbilicus.

The Two Lateral False Ligaments pass from the sides of the bladder, which they leave at the level of the obliterated hypogastric arteries, to the iliac fossæ.

The Two Posterior False Ligaments pass backwards from the bladder along the sides of the rectum. They are produced by the raising up of the peritoneum by the obliterated hypogastric arteries. These two ligaments bound the sides of the recto-vesical peritoneal pouch, and each ligament contains between its two layers the superior vesical artery, the obliterated hypogastric artery, the ureter, and some filaments from the pelvic plexus of the sympathetic.

All the peritoneal or false ligaments of the bladder are produced by the raising up of the peritoneum from the bladder by the obliterated hypogastric arteries passing forwards from the back of the pelvis to the apex of the bladder, and thence on to the umbilicus. Were these vessels not present there would be no false ligaments of the bladder.

Arteries of the Bladder.—The arteries of the bladder are always four, and by no means infrequently six in number. They are as follows:—

The Superior Vesical Arteries are, at their commencement, the remaining pervious portions of the obliterated hypogastric arteries of the fœtus. In the adult they appear as direct branches of the internal iliac arteries. They supply the apex and body of the bladder.

The Inferior Vesical Arteries.—These arteries, branches from the internal iliac artery, supply the base of the bladder and the neighbouring parts.

The Middle Vesical Arteries are inconstant; when present they are usually derived from the superior vesical arteries.

Besides the above vessels, numerous small unnamed twigs are given to the bladder by most of the branches of the internal iliac artery.

Veins of the Bladder.—The veins of the bladder differ somewhat from its arteries, inasmuch as, instead of being distinct venous trunks, they are collected together into large plexuses situated round the neck, sides, and base of the bladder. Posteriorly they pass into the internal iliac veins.

Nerves of the Bladder.—The nerves, like the vessels, are bilateral. They are derived from the sacral plexus and the hypogastric sympathetic plexus.

Lymphatics of the Bladder.—The lymphatics accom-

pany the veins, and terminate in glands situated near the iliac arteries.

The Ureters.—The ureters enter the pelvis by passing in front of either the common iliac or external iliac vessels behind the peritoneum.

The right ureter lies behind the ileum, and the left ureter behind the sigmoid flexure.

Having reached the pelvis, each ureter then passes forwards and inwards below the level of the obliterated hypogastric artery, in the double fold of peritoneum which forms the posterior false ligament of the bladder, until it reaches the base of the bladder at its upper and outer part, and about two inches above the prostate gland. Just before entering the base of the bladder, each ureter is crossed, in the male, from without inwards, by the vas deferens, which passes down between the ureter and the bladder.

As seen from behind, the two ureters enter the base of the bladder about two inches apart, and about two inches above the prostate. They pass very obliquely through the wall of the bladder for about three-quarters of an inch, and terminate on the inner surface of that viscus by two narrow slit-like orifices.

The Vas Deferens.—The vasa deferentia constitute the excretory ducts of the testicles.

Each vas deferens commences at the lower end of the epididymis, from whence it ascends along the back of the testicle and on the *inner* side of the epididymis, and then, forming one of the contents of the spermatic cord, it passes almost vertically upwards to the external abdominal ring. In this part of its course the vas deferens lies behind the various structures which form the spermatic cord, and in this situation it can be readily distinguished by the touch, as it feels somewhat like a piece of whip-cord.

Having entered the external abdominal ring, the vas deferens then runs along the inguinal canal to the internal abdominal ring, where it leaves the other constituents of the spermatic cord by turning downwards and inwards into the pelvis, hooking round to the *inner* side of the deep epigastric artery, and descending on the *inner* side of the external iliac vessels.

Within the pelvis the vas deferens is continued downwards under cover of the peritoneum on each side of the bladder, where it crosses the obliterated hypogastric artery. Then passing to the *inner* side of the ureter, it descends on the *inner* side of the seminal vesicle, and terminates just above the base of the prostate by joining the seminal vesicle to form the common ejaculatory duct. The vas deferens is about twelve inches in length.

The Seminal Vesicles.—The seminal vesicles are two membranous receptacles, situated, one on each side, between the base of the bladder and the second part of the rectum.

Each seminal vesicle is somewhat pyramidal in form, with the larger end turned upwards towards the ureter, and the lower end at the base of the prostate.

The upper extremities of the seminal vesicles are widely separated from each other, but below they converge so as to approach the vasa deferentia, which lie to their inner side, and, uniting with these structures, they form the *common ejaculatory ducts.*

The seminal vesicles and the vasa deferentia together form the lateral boundaries of the external trigone of the bladder, and in this situation both the seminal vesicles and the vasa deferentia lie between the base of the bladder and the second part of the rectum, whilst the seminal vesicles are bound to the base of the bladder and separated from the rectum by the recto-vesical fascia.

The seminal vesicles are two sacculated structures for the reception of semen. Their sacculated appearance is due to their peculiar formation, as each vesicle is, in reality, a tube of about five inches in length, which is folded on itself and embedded in fibrous tissue.

The Common Ejaculatory Ducts.—The common ejaculatory ducts are two in number. They are formed on each side by the junction, at an acute angle, of the seminal vesicle with the vas deferens, just above the base of the prostate.

From this origin the common ejaculatory ducts pass downwards, forwards, and inwards, through the substance of the prostate, between its middle and lateral lobes, to open, after a course of one inch, in the prostatic urethra.

Their termination in the prostatic urethra is by means of two minute slit-like orifices, on the elevation termed the *verumontanum*, on either side of the sinus pocularis. The common ejaculatory ducts convey the fluid contained in the seminal vesicles and vasa deferentia into the urethra.

The Prostate Gland.—The prostate gland is a firm, glandular, and muscular body which surrounds the first or prostatic portion of the urethra, but which belongs primarily to the male organs of generation. It is a single and median structure which is situated in the pelvis, between the bladder above and the parietal pelvic fascia below. In front there is the symphysis pubis, and behind the second part of the rectum and the rectal ampulla. It is traversed by the urethra and the common ejaculatory ducts.

Shape.—The prostate is usually compared, in size and shape, to a chestnut. It is somewhat triangular, and is slightly flattened from before backwards; the base is uppermost, and its longest axis passes from above downwards and forwards, forming an angle with the vertical plane of about 25°.

Dimensions.—The dimensions of the prostate vary with the sexual age; thus in the infant and child the prostate is small; at the age of puberty it becomes considerably enlarged, attaining its completed development about the twenty-fifth year. From this onward, until about the fiftieth year, the size of the prostate remains fairly constant, but thereafter the prostate perceptibly increases in *inverse ratio* to the gradual diminution of the sexual power; thus, senile hypertrophy of the prostate is almost invariable in the aged.

When completely developed, the average size of the prostate is about one and a quarter inches in its vertical diameter, one and a half inches at its base, and half that from before backwards. These diameters will always vary according to the distended or empty conditions of the bladder and rectum.

Description.—The prostate gland may be described as possessing a base, an apex, anterior and posterior surfaces, and two lateral margins. The relations of the prostate are of the greatest practical importance, and must be most carefully studied.

The Base. — The base of the prostate is somewhat irregular, and looks upwards and slightly forwards.

The most anterior part of the base of the prostate is in contact with the neck of the bladder; behind this is a slight upward projection—the middle lobe of the prostate; and its most posterior part is traversed by the common ejaculatory ducts.

The Apex.—The apex of the prostate rests upon the parietal pelvic fascia. It is a little below the level of the lower or posterior border of the symphysis pubis, from which it is separated by a distance of about three-quarters of an inch.

The Anterior Surface. — The anterior surface of the prostate or the pubic surface is slightly convex, and lies about half an inch behind the symphysis pubis, from which it is separated by the pubo-prostatic ligaments of the bladder, a venous plexus, and some cellular tissue.

The Posterior Surface.—The posterior or rectal surface of the prostate looks backwards and downwards. It is larger and more oblique than the anterior surface, and down the middle line there is a shallow groove indicating the division of the prostate into right and left lobes.

This surface of the gland is only separated from the second part of the rectum by the visceral layer of the pelvic fascia, consequently the gland can be felt per rectum.

The Lateral Borders.—The lateral borders of the prostate are firmly supported on each side by those portions of the levatores ani muscles which are sometimes referred to as the *levator prostatæ* muscles, from which they are separated by the visceral layer of the pelvic fascia. Between the gland and this fascia there is the prostatic venous plexus.

Structures Traversing the Prostate.—The substance of the prostate is traversed by the urethra and the common ejaculatory ducts.

The *urethra* passes from the neck of the bladder almost vertically downwards to the apex of the prostate, rather nearer its anterior surface than its posterior, consequently this part of the urethra is termed the prostatic urethra.

The *common ejaculatory ducts* traverse the gland close

together from behind forwards, to open into the prostatic urethra.

Projecting backwards into the substance of the prostate from the prostatic urethra is the blind cul-de-sac—the *sinus pocularis.*

Lobes of the Prostate. — The prostate is usually described as consisting of three lobes, middle and two lateral. The *lateral lobes* form the greater part of the gland, whilst the *middle lobe* is formed by that portion of the gland which lies between the urethra and the bladder; it is best seen in a sagittal section of the prostate.

Capsule of the Prostate.—The prostate is surrounded by a dense resisting capsule, formed by the vesical, recto-vesical, and parietal pelvic fasciæ. Hence inflammatory affections of the prostate, when acute, are extremely painful.

Prostatic Venous Plexus.—The veins of the prostate form a well-marked venous plexus surrounding the gland, and lying between the gland and its fibrous capsule.

Opening into the plexus *in front* is the dorsal vein of the penis, whilst *posteriorly* the venous blood passes from the prostatic venous plexus into the internal iliac veins. This prostatic venous plexus is considerably developed in elderly people.

The Interior of the Bladder.—If the bladder be laid open from the front, the vesical orifice of the urethra will be seen at the neck of the viscus, around which the mucous membrane is corrugated longitudinally.

One and a half inches above and to the outer side of this orifice are the slit-like orifices of the ureters. These three points constitute the three angles of an equilateral triangle, the sides of which are formed by imaginary lines drawn between the three points mentioned. The circumscribed area constitutes the *internal trigone of the bladder.* On account of the obliquity with which the ureters pass through the bladder wall, the internal trigone is rather smaller than the external trigone. The mucous membrane of the bladder within the internal trigone is said to be more sensitive than elsewhere.

The Urethra.—The urethra is the excretory canal for the urine and semen. It commences at the vesical orifice and terminates at the meatus urinarius, and is about eight inches long. The urethra may be divided into a *urinary* portion, extending from the vesical orifice to the openings of the common ejaculatory ducts, and a *uro-genital* portion extending from that point on to the meatus urinarius; but it is more usual to subdivide the urethra into three parts—a prostatic portion, a membranous portion, and a spongy or penile portion.

The Prostatic Urethra.—The prostatic urethra, or the first part of the urethra, extends from the vesical orifice of the urethra to the apex of the prostate gland. It is about one inch and a quarter in length, is entirely surrounded by the prostate, and lies altogether above the deep perineal pouch.

The prostatic urethra passes almost vertically downwards through the prostate, rather nearer its anterior surface than its posterior, and is the widest and most dilatable part of the urethra. It is wider at the middle than at either end, and in transverse section it is curved, with the convexity forwards.

If the prostatic urethra be laid open from the front, and its posterior wall examined, a vertical elevation, the *verumontanum,* is distinctly visible.

The verumontanum is a fold or elevation of the mucous membrane, three-quarters of an inch in length and one-eighth of an inch at its greatest height. The verumontanum becomes continuous above, with a somewhat similar fold in the bladder termed the *uvula vesicæ.*

On either side of the verumontanum, in the posterior wall of the prostatic urethra, there is a depression, the *prostatic sinus,* into which open the numerous minute orifices of the *prostatic ducts.*

Situated upon the highest part of the verumontanum, and exactly in the middle line, there is a blind recess passing backwards into the substance of the prostate for about half an inch, and which is termed the *sinus poecularis.* It corresponds to the vagina and uterus of the female, whilst its prominent lateral lips are supposed to represent the hymen.

Upon these prominent lateral lips of the sinus pocularis, and therefore upon the verumontanum, are the minute openings of the *common ejaculatory ducts.*

The Membranous Urethra. — The membranous urethra extends from the apex of the prostate to the triangular ligament.

It is about three-quarters of an inch in length, is surrounded by the compressor urethræ muscle, and lies in the deep perineal pouch.

The membranous urethra curves downwards and forwards behind and below the lower or posterior border of the symphysis pubis, from which it is about one inch distant. The posterior convex surface of the membranous urethra is turned towards the rectum, while on either side of it, and lying in the deep perineal pouch, are Cowper's glands. The membranous urethra is the shortest part of the urethra, and is very narrow.

The Spongy or Penile Urethra.—The spongy or penile portion of the urethra extends from the triangular ligament to the meatus urinarius. It is about six inches in length, and is embedded throughout in the corpus spongiosum of the penis.

At the *meatus urinarius* the spongy urethra appears as a vertical fissure which is the narrowest part of the entire urethra, hence the difficulty sometimes experienced in the introduction of large catheters or bougies into this part of the urethra.

In the glans penis the spongy urethra expands somewhat, forming the *fossa navicularis*; this is about half an inch in length.

The succeeding portion of the spongy urethra, as far as the bulb of the penis, is of uniform calibre, and in section appears as a transverse fissure, having a diameter of about a quarter of an inch, and being intermediate in size between the membranous urethra and that part of the spongy urethra which lies within the bulb.

Lastly, the spongy urethra in the bulb of the penis is somewhat dilated, constituting the *sinus of the bulb.*

The lining membrane of the urethra is, almost throughout its whole extent, occupied by small mucous glands and follicles, termed the *glands of Littrè.* In addition to these there are larger recesses, termed the *lacunæ*, which open forwards into the canal, and which are more especially abundant in the floor of the urethra, and chiefly in the bulb. Lastly, there is a somewhat larger space in the upper surface of the fossa navicularis, termed the *lacuna magna.* The point of a small catheter may be caught in this.

Opening into the floor of the spongy urethra in the bulb are the very minute orifices of Cowper's glands.

The Rectum.—The rectum is the terminal portion of the large intestine. It commences opposite the pelvic brim, at the left sacro-iliac articulation, as the direct continuation of the sigmoid flexure. It terminates at the anus, and is about eight inches in length. The sigmoid flexure corresponds to the wall of the false pelvis, and the rectum to the wall of the true pelvis.

When viewed *from the front*, the rectum is seen to curve from the left sacro-iliac articulation downwards and to the right, until it reaches the middle line of the body opposite the middle of the third sacral vertebra, from whence, onwards to its termination, it remains in the middle line of the body.

When viewed *from the side*, the rectum presents two curvatures—an upper large curvature, which sweeps round the base of the bladder and the prostate, and is concave forwards; and a second smaller curvature, concave backwards, which extends from the last curve to the anus.

The rectum is somewhat arbitrarily divided into three parts—first, second, and third.

The First Part of the Rectum.—The first part of the rectum commences at the left sacro-iliac articulation, and passing downwards, backwards, and to the right, ends opposite the middle of the third sacral vertebra.

It is about four inches in length, and is entirely surrounded by peritoneum, which forms, for this portion of the gut, a *meso-rectum.*

Behind and above the first part of the rectum are the

sacrum, the pyriformis muscle, and the sacral plexus of the left side.

To its left side are the left ureter and the branches of the left internal iliac artery.

In front there are usually some coils of small intestine, and very frequently the sigmoid flexure in addition; whilst in the female the uterus may also be in contact with this surface of the first part of the rectum.

The Second Part of the Rectum.—The second part of the rectum extends from the middle of the third sacral vertebra to the apex of the prostate gland. It is about three inches in length, and is covered by peritoneum at the sides and front, in its upper half only. The lower half of the anterior surface, and the whole of the posterior surface of the second part of the rectum, are altogether devoid of peritoneum. Immediately below the point at which the peritoneum is reflected from off the anterior surface of this part of the rectum on to the bladder, the rectum pierces the recto-vesical fascia.

The *anterior* relations of the second part of the rectum are of the greatest practical importance. They are, from above downwards, the *recto-vesical peritoneal pouch*, which separates the rectum from the bladder. Below this the rectum is only separated from that portion of the base of the bladder which lies within the limits of the *external trigone* by the recto-vesical portion of the visceral layer of the pelvic fascia; whilst, lastly, the second part of the rectum is in contact anteriorly with the posterior surface of the *prostate*.

In the female the second part of the rectum is in contact anteriorly with the pouch of Douglas and the posterior wall of the vagina.

The *posterior* relations of the second part of the rectum are, from above downwards, the sacrum, the coccyx, and the ano-coccygeal body.

On either side of the second part of the rectum are the coccygeal muscles.

The termination of the second part of the rectum, that is, its junction with the third part or anal canal, is marked by a dilatation, termed the *rectal ampulla*, which is capable of considerable distension.

The Anal Canal.—The third and last portion of the rectum is situated in the perineum outside the pelvis. It is usually termed the anal canal. The anal canal commences at the apex of the prostate, and runs backwards and slightly downwards for about one inch, to terminate at the anus.

The anal canal, which is surrounded by the two sphincter muscles, is described by Symington as being an antero-posterior slit in the pelvic floor.

It is bounded *behind* by the ano-coccygeal body, on *either side* by the levatores ani muscles, external to which is the fat of the ischio-rectal fossæ. *In front*, in the male, there are, from above downwards, the apex of the prostate gland, the membranous urethra, and the bulb of the urethra.

In the female the anal canal is separated from the vulva and lower part of the vagina by the perineal body.

The anal canal is surrounded in its whole extent by certain powerful muscles. These muscles are the internal sphincter ani in almost its whole extent; and external to this the levator ani in its upper part, and the external sphincter ani in its lower part. The tonic contraction of these muscles maintains the walls of the anal canal in constant apposition, except during the act of defæcation. The normal influence of these muscles upon the anal canal is also of some practical importance, as it is obviously imperative to introduce enemata which are to be retained by the patient, sufficiently far into the rectum to be beyond the influence of these circum-anal muscles.

General and Practical Points concerning the Rectum.—The calibre of the rectum is not uniform throughout. At its commencement the calibre of the rectum equals that of the lower part of the colon, but, as the rectum descends, its calibre increases until, at the termination of the second part of the rectum (apex of prostate) it reaches its maximum size in a dilatation termed the *rectal ampulla.* In the anal canal the calibre of the rectum may be said to be non-existent, as its walls are always in contact except during defæcation.

The peritoneal relations of the rectum are very important. The peritoneum is usually reflected from the anterior surface of the second part of the rectum opposite the middle of the

fifth sacral vertebra, consequently it is possible to resect from behind some three inches or more of the lower end of the rectum, without wounding the peritoneum.

The Internal Surface of the Rectum.—The mucous membrane of the rectum is more freely movable on the muscular coat than in other parts of the large intestine, hence the possibility of prolapsus ani. When the rectum is empty and contracted the mucous membrane is thrown into numerous folds, some of which are merely temporary whilst others are of a more permanent character. The latter are usually termed the "*valves of the rectum*," or the "*rectal folds of Houston*." The largest of these folds is usually situated on the right side, opposite the most dependent point of the recto-vesical pouch. A knowledge of these rectal folds is of some practical importance when introducing rectal bougies. In the anal canal the mucous membrane is thrown into a series of vertical folds termed the "*columns of the rectum*."

Lastly, it is important to remember that the small blood vessels in the anal canal lie within these columns of the rectum, and therefore between the muscular and mucous coats, and, being unsupported, are consequently peculiarly liable to become varicose, producing *hæmorrhoids.*

The Vessels of the Rectum.—The arteries of the rectum are five in number, derived from three sources:—

(1) The superior hæmorrhoidal artery, a single unpaired vessel, is derived from the inferior mesenteric artery, of which vessel it is the continuation into the pelvis.

(2) The middle hæmorrhoidal arteries, two in number, are derived from the internal iliac artery.

(3) The inferior hæmorrhoidal arteries, also two in number, are derived from the internal pudic arteries, and cross the ischio-rectal fossæ to reach the lower end of the rectum and anus.

The Superior Hæmorrhoidal Artery. — The superior hæmorrhoidal artery extends from the upper to the lower end of the rectum. Reaching the upper extremity of the rectum, between the two layers of the meso-rectum, it there divides into two branches. These two branches subdivide into other branches, which pierce the muscular coat of the rectum and run downwards longitudinally between the muscular coat and the mucous membrane as far as the anus.

The Middle Hæmorrhoidal Arteries.—The middle hæmorrhoidal arteries are very variable in size, and although they supply the rectum, their principal branches are destined for the supply of the prostate and seminal vesicles.

The Inferior Hæmorrhoidal Arteries.—These are described with the perineum. (*See* page 5.)

The Superior Hæmorrhoidal Vein.—The superior hæmorrhoidal vein, a single unpaired structure, commences in small venous dilatations, situated at the lower end of the rectum between the mucous membrane and the muscular coat. From this origin the venous radicles pass upwards for about three inches, communicating freely with one another and with the other veins of the rectum, forming the hæmorrhoidal venous plexus. These veins then pierce the muscular coat, from which they emerge as the superior hæmorrhoidal vein; this passes upwards as the inferior mesenteric vein, which in its turn opens into the splenic vein, and so into the portal system.

The Middle Hæmorrhoidal Veins.—The middle hæmorrhoidal veins receive few tributaries from the rectum. They drain principally the surrounding structures, and ultimately terminate in the internal iliac vein.

The Inferior Hæmorrhoidal Veins.—The inferior hæmorrhoidal veins, by means of their venous radicles, form a transverse plexus around the lower end of the rectum, which anastomoses with the longitudinal venous plexus formed by the superior hæmorrhoidal vein. The inferior hæmorrhoidal veins then traverse the ischio-rectal fossa, and terminate in the internal pudic veins.

In connection with the vascular supply of the rectum there are certain important points to be noted:—

The principal vascular supply of the rectum is by means of the superior hæmorrhoidal vessels. The other hæmorrhoidal vessels are of very secondary importance.

Both the arterial and venous capillaries lie, within the lower three inches of the rectum, between the mucous and muscular coats.

The greater part of the venous blood from the rectum is conveyed by means of the superior hæmorrhoidal vein into the portal system, and a smaller part only into the systemic veins by means of the middle and inferior hæmorrhoidal veins. These anatomical facts require careful consideration in connection with the production of hæmorrhoids, and explain the frequency of this disease in connection with liver affections.

Lymphatics of the Rectum.—The lymphatic vessels from the rectum accompany the superior hæmorrhoidal vessels into certain small lymphatic glands, situated in the concavity of the sacrum, and then upwards into the lumbar glands.

Nerve Supply of the Rectum.—The nerves of the rectum are derived from the sacral plexus, and from the inferior mesenteric and hypogastric sympathetic plexuses.

The Pelvic Arteries.—The arteries of the pelvis may be classified as follows:—

Those Arising within the Pelvis.

- The internal iliac artery and its branches.

Those Entering the Pelvis from other Regions.

- The superior hæmorrhoidal artery, the continuation into the pelvis of the inferior mesenteric artery.
- The ovarian artery, from the abdominal aorta.
- The middle sacral artery, the continuation into the pelvis of the abdominal aorta.

The Internal Iliac Artery.—The internal iliac artery commences opposite the lumbo-sacral articulation by the bifurcation of the common iliac artery into internal and external iliacs. From this origin the internal iliac runs downwards and slightly backwards for about one and a half inches, to terminate opposite the upper border of the great sacrosciatic foramen by dividing into an anterior and a posterior division, or more frequently by breaking up into its branches in an irregular manner.

Relations.—In the above course the artery rests upon the inner border of the psoas muscle, the sacrum, the lumbo-sacral cord, and the internal iliac vein. In front, it is covered by peritoneum, and near the origin of the artery it is crossed by the ureter. The companion vein lies behind and rather to the inner side of the artery.

Branches.—The branches of the internal iliac artery are nine in number, and are either parietal or visceral. The parietal branches are again subdivided into intrapelvic and extrapelvic branches, so that the branches of the internal iliac artery may be grouped as follows:—

EXTRAPELVIC PARIETAL BRANCHES.
  The obturator artery.
  The gluteal artery.
  The sciatic artery.
INTRAPELVIC PARIETAL BRANCHES.
  The internal pudic artery.
  The ilio-lumbar artery.
  The lateral sacral arteries.
VISCERAL BRANCHES.
  The superior vesical artery.
  The inferior vesical artery.
  The middle hæmorrhoidal artery.

Extrapelvic Parietal Branches.—*The Obturator Artery.*—The obturator artery runs downwards and forwards on the lateral wall of the pelvis, a little below the ilio-pectineal line and the obturator nerve. It rests at first upon the obturator portion of the parietal pelvic fascia, being covered by peritoneum. As the upper line of attachment of the parietal pelvic fascia gradually sinks, the artery passes above it, and at the obturator foramen the artery passes out of the pelvis through the obturator groove on the under surface of the anterior or ascending ramus of the pubis. It is consequently the only artery which leaves the pelvis without piercing the parietal pelvic fascia.

Having gained the exterior of the pelvis the artery immediately divides into external and internal terminal branches, which surround the obturator foramen lying between the obturator membrane and the obturator externus muscle.

In connection with the surgery of femoral hernia, it is very important for the student to remember that the origin

of the obturator artery is abnormal in two out of every five subjects.

The practical significance of these abnormal origins consists in the fact that in the proportion of cases just given the obturator artery arises, not from the internal iliac artery, but from the deep epigastric artery as fully described on page 43.

Within the pelvis, the obturator artery gives off *muscular* branches and a small *pubic* branch, which anastomoses with the pubic branch of the deep epigastric artery.

The Gluteal Artery.—The gluteal artery, the largest branch given off by the internal iliac artery, runs obliquely downwards and backwards, between the lumbo-sacral cord and the anterior primary division of the first sacral nerve, to leave the pelvis through the great sacro-sciatic notch *above* the pyriformis, to be distributed to the muscles on the outer side of the pelvis. The vessel may be recognised within the pelvis by its large size, and its relation to the nerves just mentioned.

The Sciatic Artery.—The sciatic artery runs vertically downwards in front of the pyriformis and the sacral plexus, to leave the pelvis through the great sacro-sciatic foramen *below* the pyriformis. At this point the vessel usually lies to the inner side of the internal pudic artery.

Intrapelvic Parietal Branches.—*The Internal Pudic Artery.*—This vessel, like the sciatic artery, descends in front of the pyriformis muscle and the sacral plexus, to leave the pelvis through the lower part of the great sacro-sciatic foramen *below* the pyriformis. It then appears in the buttock, where it crosses the apex of the spine of the ischium, and enters the perineum through the small sacro-sciatic foramen.

The Ilio-Lumbar Artery.—The ilio-lumbar artery passes upwards, backwards, and outwards, between the obturator nerve and the lumbo-sacral cord to the upper end of the ilio-pectineal line. In this course it passes behind the psoas muscle, behind which it terminates by dividing into an ascending or lumbar branch and a transverse or iliac branch.

(*a*) *The Ascending or Lumbar Branch* runs upwards towards the lumbar vertebræ, under cover of the psoas muscle, to supply that muscle and the quadratus lumborum. It gives off a *spinal* branch and anastomoses with the lower lumbar arteries.

(*b*) *The Transverse or Iliac Branch* runs horizontally outwards behind the psoas and then divides into two branches, one lying between the iliacus muscle and the fascia covering it, supplying that muscle and anastomosing with the deep circumflex iliac artery; and the other lying between the muscle and the iliac bone, and supplying the muscle, the bone, and the periosteum.

The Lateral Sacral Arteries.—The lateral sacral arteries are usually two in number on each side.

The *superior lateral sacral* artery passes transversely inwards, and, after anastomosing with the middle sacral artery, turns backwards through the first anterior sacral foramen, and, escaping on the back of the sacrum, supplies the muscles and skin over the posterior part of the pelvis.

The *inferior lateral sacral* artery passes in front of the pyriformis and the sacral plexus, and then runs down the lateral border of the sacrum to anastomose in front of the coccyx with the middle sacral artery. In this course the artery passes downwards, internal to the anterior sacral foramina, and gives off three series of branches—one set running outwards to supply the pyriformis and coccygeus muscles and the sacral nerves; a second set, running inwards in front of the sacrum, anastomose with the middle sacral artery; and a third set, running backwards through the anterior sacral foramina, supply the sacral canal, and, emerging at the posterior sacral foramina, supply the muscles and skin on the back of the sacrum, and anastomose with the gluteal and sciatic arteries.

Visceral Branches.—*The Superior Vesical Artery.*—The superior vesical artery, often represented by several twigs, is at its commencement a pervious part of the obliterated hypogastric artery. It passes forwards in the posterior false ligament of the bladder, and divides into numerous branches which supply the apex and body of that viscus.

The most posterior of these branches is sometimes termed the *middle vesical* artery, in addition to which the superior vesical *occasionally* gives off the *artery to the vas deferens.*

The Inferior Vesical Artery, or the Vesico-Prostatic Artery.—This vessel passes downwards to the base of the bladder, and supplies the neck and base of the bladder, the prostate, and the vesiculæ seminales.

It *usually* gives off the small but constant artery to the vas deferens, one of the constituents of the spermatic cord.

The Middle Hæmorrhoidal Artery.—The middle hæmorrhoidal artery, very variable both in size and origin, runs downwards and inwards towards the rectum. After giving off a few branches to that viscus, which anastomose with the superior hæmorrhoidal, the vessel is continued onwards to the bladder, the base of which it supplies, as well as the vesiculæ seminales, and the lateral borders of the prostate.

This vessel frequently arises from either the inferior vesical or the internal pudic arteries.

The Superior Hæmorrhoidal Artery.—(*See* page 169.)

The Ovarian Artery.—(*See* page 194.)

The Middle Sacral Artery.—This small vessel is the continuation of the abdominal aorta into the pelvis. It passes downwards in the middle line, in front of the last lumbar vertebra, the sacrum, and the coccyx, to the coccygeal gland. It anastomoses with the lateral sacral arteries.

The Internal Iliac Artery in the Fœtus.—The internal iliac artery in the fœtus differs very considerably from the same vessel in the adult.

In the fœtus the internal iliac artery is a large vessel, about twice the size of the external iliac, and is usually termed the *umbilical* artery.

The fœtal umbilical artery commences opposite the lumbosacral articulation by the bifurcation of the common iliac artery into external iliac and umbilical or internal iliac arteries. It terminates in the placenta.

In their course between their origin and termination the umbilical arteries pass forwards on either side of the rectum and bladder at some little distance above the pelvic floor; in this way the vessels lift the peritoneum off the bladder and so form the *posterior* and *lateral false ligaments* of that viscus.

At the apex of the bladder the umbilical arteries are only separated from one another by the urachus. The three structures ascend to the umbilicus, and together raise up the peritoneum from off the deep surface of the anterior abdominal wall, forming in this way the *superior false ligament* of the bladder.

The umbilical arteries convey the mixed and impure blood of the fœtus to the placenta, to be oxygenated there.

After birth, when the umbilical cord is ligatured and divided, the umbilical arteries become filled with blood clot, and, rapidly becoming obliterated, remain in the adult as fibrous cords which are known as the *obliterated hypogastric arteries.*

The only portions of the fœtal umbilical arteries which remain pervious in the adult are the proximal ends, just where they arise from the umbilical or internal iliac arteries of the fœtus. These pervious portions form part of the *superior vesical arteries* of the adult.

The Veins of the Pelvis.—The veins of the pelvis correspond very closely to the arteries, but there are, nevertheless, certain important differences to be noted.

The dorsal vein of the penis passes backwards, below the symphysis pubis, and divides into two, each of which terminates in the prostatic venous plexus on either side of the prostate.

The middle sacral veins, two in number, unite to form a single vessel, which terminates in the left common iliac vein.

The ilio-lumbar vein terminates, on each side, in the common iliac vein.

The Pelvic Plexuses.—The pelvis is peculiarly rich in venous plexuses. The three most important pelvic venous plexuses are the prostatic, vesical, and hæmorrhoidal.

The *prostatic and vesical plexuses* are freely continuous. They are formed chiefly by the dorsal vein of the penis passing backwards to open into the prostatic plexus on either side of the prostate. Posteriorly, the blood is drained away by the vesical veins, which terminate in the internal iliac vein.

The *hæmorrhoidal venous plexus* surrounds the anal canal, and lies between the muscular coat and the mucous membrane. From this plexus the blood passes into the

portal system of the liver by means of the superior hæmorrhoidal vein; into the internal iliac vein by the middle hæmorrhoidal vein; and into the internal pudic vein by the inferior hæmorrhoidal. The hæmorrhoidal plexus is therefore an important connection between the portal and systemic venous systems.

The Internal Iliac Vein.—The internal iliac vein is formed by the junction of tributaries which correspond almost entirely to the branches of the artery. The vein lies behind and to the inner side of the artery, and terminates by joining the external iliac vein to form the common iliac vein. There are no valves in the trunk of the internal iliac vein.

Tributaries.—The tributaries of the internal iliac vein correspond to the branches of the artery, with the single exception of the ilio-lumbar vein, which, as stated, terminates in the common iliac vein.

The Sacral Plexus.—The sacral plexus is formed by the junction of the following nerves:—

The lumbo-sacral cord.
The anterior primary divisions of the first three sacral nerves.
Part of the anterior primary division of the fourth sacral nerve.

The Lumbo-Sacral Cord.—The lumbo-sacral cord is formed by the junction of the descending part of the anterior primary division of the fourth with the whole of that of the fifth lumbar nerve. It passes downwards into the pelvis in front of the base of the sacrum, to take part in the formation of the sacral plexus.

The Anterior Primary Divisions of the First Three Sacral Nerves.—The first two nerves are of nearly equal size, but the third, as well as the fourth and fifth, diminish in size; they make their appearance through the anterior sacral foramina.

The Fourth Sacral Nerve.—This nerve takes part in the formation of both the sacral and the sacro-coccygeal plexuses. In addition to this, the nerve also gives off branches as follows:—

Visceral branches to the bladder and vagina, and to the sympathetic system in the pelvis.

- Muscular branches.
  - To the levator ani muscle.
  - To the coccygeus muscle.
  - To the external sphincter ani muscle.

As this last nerve is the only one of the three muscular branches given off by the fourth sacral nerve, which leaves the pelvic cavity and enters the perineum, it is frequently referred to as the *perineal branch of the fourth sacral nerve.* It leaves the pelvis between the levator ani and coccygeus muscles, or by piercing one of these muscles near the coccyx.

The sacral plexus, having been formed in this manner, converges towards the great sacro-sciatic foramen. It rests upon the pyriformis muscle, behind the sciatic and internal pudic arteries, from which it is separated by the parietal pelvic fascia.

The plexus divides into an upper and larger band, formed principally by the junction of the lumbo-sacral cord with the first, second, and greater part of the third sacral nerves, and a lower and smaller band formed by the remaining nerves of the plexus. Both these bands leave the pelvis through the great sacro-sciatic foramen below the pyriformis, and terminate at the lower border of that muscle by becoming, respectively—the upper band, the great sciatic nerve; and the lower band, the pudic nerve.

Branches of the Sacral Plexus.—These are as follows:—

- Small muscular branches.
  - To the pyriformis muscle, from the back of the first and second sacral nerves.
  - The nerve to the quadratus femoris muscle, from the lumbo-sacral cord and the first sacral nerve.
  - The nerve to the obturator internus muscle, from the fifth lumbar and the first and second sacral nerves.
- The superior gluteal nerve, from the lumbo-sacral cord and the first sacral nerve.
- The inferior gluteal nerve, from the lumbo-sacral cord, and the first and second sacral nerves.
- The small sciatic nerve, from the first, second, and third sacral nerves.

The perforating cutaneous branch, from the second and third sacral nerves.

Terminal branches.

The great sciatic nerve.

The pudic nerve.

The Sacro-Coccygeal Plexus.—This small plexus is formed by the junction of the anterior primary divisions of the remaining part of the fourth sacral nerve, the fifth sacral, and the coccygeal nerve.

The anterior primary division of the fifth sacral nerve passes forwards through the coccygeus muscle, between the sacrum and the coccyx, and then descends upon the coccygeus muscle until it is joined by the anterior primary division of the coccygeal nerve, after which junction the nerve trunk so formed turns backwards near the tip of the coccyx, pierces the coccygeus muscle, the great sacro-sciatic ligament, and the gluteus maximus muscle, to end on the posterior surface of the coccyx.

The Sympathetic System in the Pelvis.—The sympathetic system in the pelvis consists of two gangliated cords and the hypogastric plexus.

The Gangliated Cords of the Sympathetic in the Pelvis.—The gangliated cords of the sympathetic are continued downwards into the pelvis from the abdomen. The two cords lie in front of the sacrum, just internal to the anterior sacral foramina, and, approaching each other as they descend, they terminate in front of the coccyx, by uniting to form the *ganglion impar.*

There are usually four ganglia on each cord, from which communicating branches are given off to the sacral nerves. Other branches are supplied to the sacrum, coccyx, the middle sacral artery, and the coccygeal body.

The Hypogastric Plexus.—The hypogastric plexus lies in the interval between the two common iliac arteries. It is formed by branches from the aortic plexus, and terminates below by dividing into two parts, which are directed downwards on each side of the rectum, and from which the various subsidiary pelvic plexuses are formed.

These subsidiary pelvic plexuses are intended for the supply of the pelvic viscera, and are as follows:—The hæmorrhoidal plexus, the vesical plexus, and the prostatic plexus. The branches from these plexuses correspond very closely to the branches of the internal iliac artery.

The Coccygeal Body.—This is a minute vascular body situated in front of the tip of the coccyx. It is formed chiefly by minute arterioles derived from the middle sacral artery. Its function, if it has any, is unknown.

The Pelvic Muscles.—The pelvic muscles are eight in number, four pairs, as follows:—

The pyriformis muscles.
The obturator internus muscles.
The levator ani muscles.
The coccygeus muscles.

The Pyriformis Muscle.—This is a flattened and triangular muscle which extends from the sacrum to the great trochanter of the femur.

Origin.—The muscle arises by three fleshy slips from the pelvic surfaces of the second, third, and fourth pieces of the sacrum, between and external to the anterior sacral foramina.

Some fibres also arise from the anterior surface of the great sacro-sciatic ligament and from the highest part of the great sacro-sciatic foramen.

Insertion.—The muscle passes out of the pelvis through the great sacro-sciatic foramen, to be inserted by a rounded tendon into the middle of the superior border of the great trochanter of the femur.

Nerve Supply.—Twigs from the sacral plexus.

Action.—The muscle, though arising within the pelvis, acts upon the hip-joint.

Intrapelvic Relations.—The pelvic surface of the muscle is in contact with the rectum, the sacral plexuses, and the pyriformis fascia, which last separates the muscle from the internal iliac vessels.

The Obturator Internus Muscle.—This is a flattened muscle situated on the intrapelvic surface of the obturator membrane, and extending from thence to the great trochanter of the femur.

Origin.—The muscle arises from the internal or intra-

pelvic surface of the obturator membrane, from the internal surface of the descending ramus of the pubis, from the internal surface of the body and ascending ramus of the ischium, and, lastly, from that quadrilateral surface of the os innominatum which is situated between the ilio-pectineal line, the obturator foramen, and the ischial spine.

Insertion.—From this extensive origin the muscular fibres converge upon the small sacro-sciatic foramen, through which the muscle leaves the pelvis. Turning round the trochlear surface of the ischium, the tendon of the muscle suddenly changes its direction, and, now passing outwards, is inserted along with the gemelli muscles into an impression on the antero-internal portion of the superior border of the great trochanter of the femur, just in front of the insertion of the pyriformis muscle.

Nerve Supply.—The nerve to the obturator internus from the sacral plexus.

Action.—Like the pyriformis, the obturator internus, though a pelvic muscle, acts upon the hip-joint.

Intrapelvic Relations.—At its lower part the muscle and the obturator fascia form one of the outer boundaries of the ischio-rectal fossa, and are here crossed by the internal pudic vessels and the other structures contained in Alcock's canal.

The Levator Ani Muscle.—This muscle is a thin flattened muscle of considerable size, which extends from the antero-lateral wall of the pelvis to the region of the anus. The two muscles meet in the middle line, and together constitute a muscular floor for the greater part of the pelvic cavity.

Origin.—The levator ani arises, from before backwards, from the deep surface of the body of the pubis between the attachments of the recto-vesical fascia, and the parietal pelvic fascia; from the upper layer of the deep perineal fascia; from the parietal pelvic fascia along the white line; and, lastly, from the spine of the ischium.

Insertion. — From this extensive origin the muscular fibres pass downwards and inwards, converging upon their insertion.

The *prerectal* fibres sweep backwards, downwards, and inwards on either side of the prostate, to be inserted into the central point of the perineum and into the ano-bulbar raphè. From the support which these fibres give to the prostate this portion of the muscle is sometimes specially named the *levator prostatæ* muscle.

The *lateral rectal* fibres pass down to the rectum between the gut and the external sphincter ani muscle.

The *postrectal* fibres are inserted into the ano-coccygeal median raphè and the tip and sides of the coccyx.

Nerve Supply.—The fourth sacral nerve and the perineal branch of the pudic.

Action.—This will be considered with the next muscle.

Relations.—The upper or *pelvic* surface of the levator ani is concave, and looks upwards and inwards. It is in contact with the recto-vesical fascia, which separates it from the peritoneum and the pelvic viscera.

The inferior or *perineal* surface is convex, and looks downwards and outwards. It is covered by the thin anal fascia, which separates it from the fat of the ischio-rectal fossa.

The internal border of the levator ani muscle, which corresponds in part to its insertion, extends from the pubis to the coccyx, and is in contact from before backwards with the capsule of the prostate, the ano-bulbar median raphè, the lateral wall of the rectum, the ano-coccygeal median raphè, and the tip of the coccyx.

The external border of the levator ani corresponds to its origin, whilst its posterior border is free, and is in contact with the anterior border of the coccygeus muscle.

The Coccygeus Muscle.—The coccygeus muscle is a small flat triangular muscle, situated behind the levator ani muscle, and extending from the ischial spine to the coccyx. It represents the abductor caudalis muscle of the lower mammals.

Origin.—The muscle arises by its apex from the internal surface and both borders of the ischial spine, from the deep surface of the lesser sacro-sciatic ligament, and from the obturator fascia.

Insertion.—From this origin the muscle passes inwards,

and is inserted by its base into the lateral borders and anterior surface of the coccyx.

Nerve Supply.—The fourth sacral nerve.

Relations.—The pelvic surface of the muscle is slightly concave, and is in contact with the parietal pelvic fascia and the rectum.

Its inferior surface is in contact with the lesser sacrosciatic ligament, with which it is intimately adherent.

Its anterior border is in contact with the posterior free border of the levator ani muscle, whilst its posterior border is in contact with the pyriformis muscle.

Action of the Levator Ani and Coccygeus Muscles.—The levator ani and the coccygeus together constitute a muscular diaphragm for the pelvis, and consequently these two pairs of muscles are known as the *pelvic diaphragm.*

The concavity of the pelvic diaphragm is directed upwards, and is thus in opposition to the concavity of the diaphragm proper; it constitutes the only movable wall of the pelvis.

When contracted the pelvic diaphragm will diminish the vertical diameter of the abdominal and pelvic cavities, and act as a means of support to the pelvic viscera, and more especially to the rectum. The levator ani may further compress the lower part of the rectum, which it thus assists in emptying, whilst the lateral rectal fibres tend to raise and expand the aperture. Some of the prerectal fibres, however, act with the sphincter in closing the anal passage.

THE FEMALE PELVIS

The pelvis of the female contains the rectum, the bladder, the ureters, and the urethra, as in the male; but it also contains, in addition, the uterus and its appendages, and the vagina. It will only be necessary to point out those differences which are found in the female pelvis.

The Pelvic Fascia.—The pelvic fascia in the female resembles, in its general arrangement, that of the male. The differences are due to the facts that in the female there is no prostate, and the visceral pelvic fascia is pierced by the vagina in addition to the rectum and urethra.

The *parietal pelvic fascia* is identical with that of the male, with the exception that that portion which roofs in the deep perineal pouch sweeps upwards upon the urethra and vagina instead of upon the prostate, to join the visceral pelvic fascia.

The *visceral pelvic fascia* only differs from that of the male in that it gives a covering to the vagina, in addition to those given in the male to the bladder and rectum. This vaginal covering corresponds to that given to the prostate.

The Peritoneum.—The peritoneum partially clothes the rectum, as in the male. It is then reflected from the second part of the rectum to the posterior surface of the vagina, and ascends over the upper third or fourth of that surface on to the posterior surface of the uterus; it then passes downwards over the anterior surface of the uterus, as far as the os uteri internum, and then on to the bladder, without again coming into contact with the vagina.

The peritoneum, in its passage over the fundus of the uterus, forms two distinct and important pouches: an anterior shallow one, between the uterus and bladder, termed the *utero-vesical* pouch; and a posterior, deeper, and much more important pouch, the *utero-rectal* pouch, or the *pouch of Douglas,* between the uterus and rectum.

From their very intimate relations to the uterus these pouches, as well as the peritoneal folds in connection with the uterus, are best considered with that organ.

The Bladder.—The bladder of the female resembles the male bladder, with the following exceptions:—The female bladder is more globular than the male viscus and the base is in contact with the vagina and cervix uteri. The vasa deferentia, the seminal vesicles, and the prostate are absent.

The Ureters.—The ureters, having entered the pelvis by crossing the iliac vessels, turn forwards, at about the level of the origins of the obturator, vesical, and uterine arteries, and then pass along the sides of the cervix uteri and upper part of the vagina to enter the base of the bladder by turning slightly inwards, in such a way that the termination of each ureter is between the anterior wall of the vagina and the base of the bladder.

Each ureter lies about three-fifths of an inch external to the cervix uteri, and is crossed opposite the level of the external os by the uterine artery, the two structures—ureter and artery—being separated from one another by a venous plexus.

The Urethra.—The female urethra is about one and a half inches in length. It is embedded in the anterior wall of the vagina, and runs from its origin at the neck of the bladder, downwards and forwards to its termination at the meatus urinarius within the vestibule, one inch behind the glans clitoridis.

The female urethra, the walls of which are always in apposition except during micturition, corresponds to that part of the male prostatic urethra which extends from the vesical orifice to the openings of the common ejaculatory ducts. It is capable of very considerable dilatation, so much so that it is possible to explore the female bladder digitally and per urethram without any permanent incontinence.

The Internal Genital Organs of the Female.—The reproductive organs of the female may be divided into the internal and the external genital organs. By the internal genital organs are meant those parts which lie above the hymen; by the external genitals, those parts which lie below the hymen. The latter are described with the female perineum. (*See* page 20.)

The internal genital organs comprise the following parts:—

The vagina.
The uterus.
The Fallopian tubes.
The ovaries.

The Vagina.—The vagina is the dilatable muscular and membranous canal which leads from the external genitals to the uterus. Its general direction is from the vulva upwards and backwards, its axis being almost parallel with the plane of the pelvic inlet.

The vagina is broader in the middle than at either extremity, and on transverse section the *middle part* is flattened from before backwards, with its anterior and posterior walls in contact. The *lower end* of the vagina is the narrowest part of the vagina, and on transverse section is somewhat H-shaped. The *upper end* of the vagina is somewhat rounded, and receives the cervical portion of the uterus; and as the posterior wall of the vagina extends rather higher up than the anterior wall, the cervix uteri appears to project into the anterior wall of the vagina.

The *anterior wall* of the vagina is about two and a half inches in length, and is in contact with the bladder and urethra. It is loosely attached to the bladder by some areolar tissue, but the urethra itself is firmly embedded in the anterior wall of the vagina. This wall of the vagina has no relation whatsoever to the peritoneum.

The *posterior wall* of the vagina is about three and a half inches in length. It is an anterior relation of the second part of the rectum, to which it is loosely attached. It is covered by peritoneum in its upper third or fourth, the point at which the peritoneum is reflected off the rectum on to the posterior wall of the vagina indicating the lowest part of the pouch of Douglas.

Below the level of the peritoneum the vagina is only separated from the rectum by the visceral layer of the pelvic fascia; and at its lower end it is separated from the anal canal by the perineal body.

The rectum is therefore a posterior relation of the vagina throughout its whole extent, the two organs being separated from one another by the following structures, in order from above downwards:—

(*a*) Peritoneum of the pouch of Douglas.
(*b*) Visceral layer of the pelvic fascia.
(*c*) The perineal body.

On *either side* of the vagina are the two levatores ani muscles, and near its upper end a small part of the ureters.

The *os uteri externum* projects into the anterior wall of the vagina near its upper part. Round this there are certain small cul-de-sacs, termed the *fornices* of the vagina. The deepest and most important of these is the posterior fornix, which lies behind and above the os uteri externum.

On the *inner surface* of the vagina, anteriorly and

posteriorly, there is a slightly elevated ridge running upwards in the middle line. These ridges are termed the *columns of the vagina*, or the *columnæ rugarum*; whilst passing off from these are numerous transverse ridges termed the *rugæ*. All these folds are better marked in nulliparous women.

The Uterus.—The uterus, or womb, is a hollow muscular organ, situated in the pelvic cavity between the bladder and the rectum. The size, shape, position, and relations of the uterus vary with gestation. The following description applies only to the adult virgin uterus:—

The *adult virgin uterus* is a somewhat pear-shaped body, flattened from before backwards, free above, but projecting into the anterior wall of the vagina below. It is about three inches in length, and presents for examination a fundus, a body, and a neck.

The Fundus of the Uterus.—The fundus of the uterus is the broad, convex upper end of the body; it forms the base of the body of the uterus, and projects upwards between the two Fallopian tubes. It is completely covered by peritoneum.

The Body of the Uterus.—The body of the uterus is distinctly triangular in outline, and presents for examination a base, a blunted apex, two surfaces, and two lateral margins.

The base of the body of the uterus forms the fundus, as just described.

The blunted apex of the uterus becomes continuous with the neck at the os uteri internum.

The anterior surface is slightly convex, and is covered throughout by peritoneum. It is separated from the bladder by the peritoneum forming the utero-vesical pouch.

The posterior surface, more convex than the anterior surface, is also covered throughout its whole extent by peritoneum. It is separated from the second part of the rectum by the peritoneum forming the utero-rectal pouch, or the pouch of Douglas.

The lateral margins of the body of the uterus correspond to the uterine attachments of the broad ligaments of the uterus. At the angle between the lateral margins and the fundus of the uterus there are the Fallopian tubes.

The Neck of the Uterus, or the Cervix Uteri.—The cervix uteri is the somewhat cylindrical portion of the uterus which passes from the body of the uterus into the vagina. It extends from the os uteri internum, which indicates its junction with the body of the uterus, to the os uteri externum within the vagina.

The cervix uteri is about one inch in length, and may be subdivided into three parts, according to its relations to the vagina; these three parts are a supravaginal portion, a vaginal portion, and an intravaginal portion.

The *supravaginal* portion passes from the body of the uterus to the anterior wall of the vagina.

The *vaginal* portion is that part which lies embedded in the anterior wall of the vagina.

The *intravaginal* portion is that part which projects into the lumen of the vagina. This portion is usually termed the *os uteri externum.* It is smooth and convex, and has a transverse aperture, by means of which the cavity of the uterus communicates with that of the vagina. That part of the os uteri externum which lies in front of the transverse aperture is termed the *anterior lip*, and is thicker and lower than that part which lies behind the transverse aperture, and which is termed the *posterior lip.* Under ordinary conditions both these lips are in contact with the posterior wall of the vagina. In nulliparous women both the lips of the os uteri externum are smooth, but after parturition they become fissured and irregular.

The internal junction of the body of the uterus with the neck is termed the *os uteri internum*, and the internal surface of the cervix uteri is ridged, like that of the vagina, by certain columns, termed the *arbor vitæ uterina.*

As the peritoneum is reflected on to the bladder from the anterior surface of the body of the uterus opposite the os uteri internum, it necessarily follows that the cervix uteri is quite devoid of peritoneum anteriorly. Its posterior surface is, however, covered by peritoneum, so that the whole of the posterior surfaces of the body and cervix of the uterus and the upper third or fourth of the posterior wall of the vagina are all covered by peritoneum.

The Peritoneal Ligaments of the Uterus.—The peritoneal ligaments are of considerable practical importance. They are as follows:—

The utero-vesical ligament, or the anterior ligament of the uterus.
The utero-rectal ligament, or the recto-vaginal ligament.
The utero-sacral ligaments.
The broad ligaments of the uterus.

The Utero-Vesical Ligament, or the Anterior Ligament of the Uterus.—This is the peritoneum which is reflected from the uterus on to the bladder. The peritoneum passes down the anterior surface of the uterus as far as the level of the os uteri internum, that is, the junction of the body of the uterus with its neck, and is then reflected on to the bladder. The pouch which is formed by this reflection of peritoneum is shallow, and is termed the *utero-vesical pouch.*

This pouch does not usually contain anything; but when the uterus is retroverted some coils of small intestine may be found therein.

The Utero-Rectal or the Recto-Vaginal Ligament.—This is the ligament which is formed by the reflection of the peritoneum from the second part of the rectum on to the posterior wall of the vagina. It constitutes the most dependent part of the *utero-rectal pouch, or the pouch of Douglas.*

This pouch is much deeper than the utero-vesical pouch, and extends downwards between the second part of the rectum posteriorly and the cervix uteri and the upper third or fourth of the posterior wall of the vagina anteriorly. It is bounded on either side by the utero-sacral ligaments, and is stated to be a little lower on the left side than on the right.

The Utero-Sacral Ligaments.—The utero-sacral ligaments are the two semilunar folds of peritoneum which bound the pouch of Douglas on either side. These ligaments pass from the cervix uteri in front, backwards on either side of the rectum, to the sacrum posteriorly. They correspond to the posterior false ligaments of the bladder of the male pelvis.

The Broad Ligaments of the Uterus.—The broad ligaments of the uterus are the two important double folds of peritoneum which pass from the lateral margins of the body of the uterus to the sides of the pelvic wall.

The two broad ligaments of the uterus, together with the uterus itself, divide the female pelvic cavity into an anterior and a posterior compartment, the former containing the bladder, and the latter the rectum, some coils of small intestine, and occasionally the sigmoid flexure.

Contents of the Broad Ligament.—Each broad ligament contains between its two layers the following structures:—

The Fallopian tube.
The ovary and its ligament.
The parovarium.
The round ligament of the uterus.
Blood vessels, lymphatics, and nerves.

Each broad ligament shows some slight trace of being subdivided into three parts: the *anterior* portion contains the round ligament of the uterus; the *middle and highest* portion contains the Fallopian tube; and the most *posterior* portion contains the ligament of the ovary.

That part of the broad ligament of the uterus which contains the Fallopian tube is sometimes termed the *meso-salpinx.* The meso-salpinx constitutes the highest and intermediate portion of the broad ligament, and lies just in front of the ovary. It is narrow internally, but broadens as it passes outwards. It surrounds the Fallopian tube, and contains between its two layers the *parovarium,* which lies between the Fallopian tube and the ovary.

The Round Ligament of the uterus.—The round ligament of the uterus is *not* a peritoneal ligament, and must not be confounded with the peritoneal ligaments of that body. The round ligaments are two flat fibrous cords, about five inches in length.

They are attached to the uterus at its upper angle, that is, at the angle between the fundus and the lateral margins of the body of the uterus, and just in front of the uterine extremities of the Fallopian tubes. From this point each round ligament passes upwards, forwards, and outwards to the internal abdominal ring, from whence it is continued onwards through the inguinal canal, through the external

abdominal ring, to become lost in the substance of the mons veneris.

The round ligaments are surrounded by the peritoneum of the broad ligament, a fold of which accompanies the ligaments into the inguinal canal, and is termed the *Canal of Nuck.* This tends to become obliterated with advancing age.

The Fallopian Tubes.—The Fallopian tubes constitute the ducts of the ovaries, inasmuch as they convey the ova from the ovaries to the uterus. They differ from all other ducts in being detached from their glands.

Each Fallopian tube is about four inches long, and extends from the upper angle of the uterus between the two layers of the broad ligament to the ovary. In this course the Fallopian tube passes horizontally outwards for about one inch to the side wall of the pelvis. It then turns upwards against the side of the pelvis, and in front of the anterior border of the ovary, until it reaches the upper extremity of that viscus, where it turns backwards; lastly, its fimbriated extremity passes downwards in contact with the posterior border of the ovary, the fimbriæ themselves being in contact with the posterior border and internal surface of the ovary.

Each Fallopian tube may be described as consisting of an isthmus, an ampulla, a neck, and a fimbriated extremity.

The *isthmus* is the inner or uterine third of the tube; it is straight, round, and cord-like. Its lumen is extremely small.

The *ampulla* constitutes about one-half of the total length of the tube. It extends from the isthmus to the neck, and is somewhat tortuous.

The *neck of the Fallopian tube*, or the ostium abdominale, is the part from which the fimbriæ radiate. It is probably closed during life, except during the passage of an ovum.

The *fimbriated extremity* consists of a number of irregular processes or fimbriæ. The fimbriæ vary considerably, but are usually in contact with the posterior border and internal surface of the ovary. One of the fimbriæ, termed the *ovarian fimbria*, is in contact with and attached to the upper extremity of the ovary.

It is important to notice that the Fallopian tubes open freely into the general peritoneal cavity; an example of the direct continuity of a mucous and a serous membrane.

The peritoneum is not, therefore, in the female an absolutely closed sac, as in the male. It communicates with the external genitals by means of the Fallopian tubes, the uterus, and the vagina. This important fact explains the serious results which may occasionally follow an attack of gonorrhœa in the female.

It is further important to notice that the Fallopian tubes—the ducts of the ovaries—are not directly continuous with their glands. This explains the occurrence of those forms of extra-uterine gestation, where the fertilised ovum, instead of passing along the Fallopian tubes into the uterus, simply drops into the general peritoneal cavity, where gestation then takes place.

The Ovaries.—The ovaries are two laterally flattened glands, situated one on each lateral wall of the pelvis, behind the broad ligament and Fallopian tube. The position of the ovary varies considerably, but it is usual to describe the ovary as lying vertically against the side wall of the pelvis, and as presenting for examination two surfaces, internal and external; two borders, anterior and posterior; and two extremities, upper and lower.

The internal surface of the ovary is free, and is overlapped by some of the fimbriæ of the Fallopian tube. This surface, on the right side, may be in contact with some coils of small intestine, and on the left side with the sigmoid flexure.

The external surface lies against the side wall of the pelvis in a very definite peritoneal fossa, the *ovarian fossa.* This fossa is bounded above by the external iliac vessels, behind and below by the ureter.

The anterior border of the ovary is attached to the broad ligament of the uterus, and the *hilum* of the ovary is situated upon this border, the various vessels and nerves of the ovary entering it at this point.

The Fallopian tube passes vertically upwards in front of the anterior border of the ovary.

The posterior border of the ovary is not so straight as the

anterior border. It is turned somewhat inwards towards the rectum, and is in contact with the fimbriæ of the Fallopian tube.

The upper extremity of the ovary is attached to the ovarian fimbria of the Fallopian tube. This extremity of the ovary is also attached to a peritoneal fold, termed the *suspensory ligament of the ovary*; in this fold the ovarian vessels and nerves pass downwards.

The lower extremity of the ovary is attached to the uterus by the *ligament of the ovary.* This ligament must not be confused with the suspensory ligament of the ovary just described, and which is attached to the upper extremity of the ovary.

The ligament of the ovary passes from the lower extremity of the ovary to the upper angle of the uterus. It is about one and a half inches in length.

Relations of the Ovary to Peritoneum.—It is sometimes questioned whether the ovary is surrounded by peritoneum or not; but it is more than probable that the ovary is *not* surrounded by peritoneum, that membrane being replaced on the ovary by a special layer of epithelium; consequently the ova, when they leave the ovary during menstruation, do not require to pierce the peritoneum.

The epithelium, which covers the ovary, is composed of pyriform or columnar cells, and has a dull appearance, totally unlike the glistening appearance presented by the peritoneum The ovarian epithelium is the remains of the germinal epithelium.

The Parovarium, or the Organ of Rosenmüller.—The parovarium is a fœtal remnant, consisting of a few scattered tubules lying between the two layers of the broad ligament of the uterus, between the Fallopian tube and the ovary. It is best seen by holding the broad ligament up to the light. The parovarium is a functionless structure, and is the homologue of the epididymis of the male.

The Rectum.—The only differences between the rectum of the male and female pelves are those of relations. The general description, as given under the male pelvis, holds good for the female.

In *the female* the anterior relations are, from above downwards:—

1. The peritoneal pouch of Douglas, which separates the first part of the rectum and the upper portion of the second part from the uterus and upper end of the vagina.

2. The visceral layer of the pelvic fascia, which separates the lower portion of the second part of the rectum from the vagina.

3. The perineal body, which separates the anal canal from the vagina.

The Pelvic Arteries.—The pelvic arteries in the female resemble those of the male. Three additional arteries, however, are present, in the female pelvis. These are:—

1. The ovarian arteries from the abdominal aorta.
2. The uterine arteries } from the internal iliac.
3. The vaginal arteries }

1. *The Ovarian Arteries.*—The ovarian arteries arise from the abdominal aorta. Their course within the abdomen closely resembles that of the spermatic arteries. They differ from those vessels, however, in two respects—they are shorter, and they do not pass out of the abdominal cavity as do the spermatic arteries.

Each ovarian artery crosses the pelvic brim between the two layers of the peritoneal suspensory ligament of the ovary, and then, turning inwards between the two layers of the broad ligament of the uterus, enters the ovary at its hilum on the anterior border.

The intrapelvic portions of the ovarian arteries are extremely tortuous, and during pregnancy the vessels become much enlarged. They supply the ovaries and the Fallopian tubes, and give off one large branch to the uterus.

2. *The Uterine Arteries.*—Each uterine artery is a branch of the anterior division of the internal iliac artery. It passes downwards and inwards to the neck of the uterus, and then ascends between the layers of the broad ligament on each side of the uterus. Opposite the level of the external os uteri the uterine artery is crossed by the ureter of the corresponding side, the two structures being only separated by a venous plexus.

The uterine artery in its upward course on each side of the uterus is exceedingly tortuous, and gives off numerous branches for the supply of the anterior and posterior surfaces of the uterus. Near their termination, opposite the fundus of the uterus, the uterine arteries are joined by the uterine branch of the ovarian artery. In this way an arterial arch is formed on each side between the layers of the broad ligament, from which branches are given off for the supply of the Fallopian tube, the broad ligament, and the round ligament of the uterus.

During pregnancy the uterine arteries become much enlarged.

3. *The Vaginal Arteries.*—Each vaginal artery arises from the anterior division of the internal iliac artery, or not infrequently from the uterine artery.

The vessel descends upon the vagina, which it supplies, also giving off branches to the neck of the bladder, the rectum, and the bulb of the vestibule.

The vaginal arteries correspond to the inferior vesical arteries of the male.

The Veins of the Pelvis.—The veins of the female pelvis closely resemble those of the male, with the following differences:—In the female there are vaginal and uterine venous plexuses, but there is, of course, no prostatic venous plexus.

The *dorsal vein of the clitoris* joins the vesical plexus.

The *vaginal venous plexus* is drained by the internal iliac veins.

The *uterine venous plexus* is drained by the ovarian veins. The plexus is small, except during pregnancy, when it enlarges considerably.

Nerves of the Pelvis.—The only differences to be noted are that in the female the prostatic nerve plexus of the male pelvis is replaced by the vaginal and ovarian nerve plexuses, and that there are numerous uterine nerves.

Muscles of the Pelvis. — The anterior fibres of the levator ani muscle support the vagina instead of the prostate.

THE THORAX

Definition.—The thorax is that part of the trunk which contains the heart and lungs.

Shape.—The thorax resembles a truncated cone standing on its base. It presents for examination a base, an upper aperture or inlet, an anterior wall, a posterior wall, and two lateral walls.

The Base of the Thorax.—The *base* of the thorax, or the *thoracic outlet,* is formed by a movable muscular partition, the diaphragm.

The diaphragm constitutes the division between the thoracic and abdominal cavities, and is pierced by the various structures passing from one cavity to the other. As the diaphragm is one of the chief muscles concerned in the act of respiration, it follows that the base of the thorax is, during life, in a state of continual movement. The transverse diameter of the base of the thorax is rather more than twice that of its antero-posterior diameter.

The *circumferential boundaries* of the thoracic outlet are as follows:—*In front,* the ensiform cartilage; from this the *lateral* circumferential boundary passes downwards, outwards, and backwards along the cartilages of the seventh, eighth, ninth, and tenth ribs. Opposite the tip of the eleventh rib the lateral circumferential boundary of the thorax changes its direction, and runs upwards, backwards, and inwards along the twelfth rib to the vertebral column, where it is bounded *posteriorly* by the twelfth dorsal vertebra.

The Upper Aperture or Inlet of the Thorax.—The upper aperture or inlet of the thorax is bounded *posteriorly* by the upper border of the body of the first dorsal vertebra; *laterally,* by the inner borders of the first pair of ribs with

their costal cartilages; *in front*, by the upper border of the manubrium sterni.

The transverse diameter of the thoracic inlet is about three and a half inches; the antero-posterior diameter, about two inches. Through this narrow aperture are transmitted numerous important structures from the neck to the thorax, and *vice versâ*.

The plane of the thoracic inlet is not horizontal, but is set obliquely in such a way that at the end of the act of expiration the upper border of the manubrium sterni is opposite the disc between the second and third dorsal vertebræ.

The Anterior Wall of the Thorax.—This wall, which is shorter than the posterior wall, is formed by the manubrium sterni, the body of the sternum, and the costal cartilages of the upper seven ribs. If this wall be viewed in profile it will be noticed that it does not lie perpendicularly, but is set obliquely in such a way that it forms an angle with a horizontal plane, such as the ground, of about 80 degrees. In the living subject this wall rises and falls with each respiration, the movement being more marked in the female (costal respiration) than in the male (diaphragmatic respiration).

The relations of the sternum to the dorsal vertebræ at the end of the act of expiration, are as follows:—

(*a*) The upper border of the manubrium sterni is opposite the disc between the second and third dorsal vertebræ.

(*b*) The junction of the manubrium sterni with the gladiolus or body of the sternum is opposite the body of the fifth dorsal vertebra.

(*c*) The xiphi-sternum, or the ensiform process, lies generally opposite the body of the tenth dorsal vertebra.

The Posterior Wall of the Thorax.—This wall is formed by the bodies of all the dorsal vertebræ and the intervening intervertebral discs, and the vertebral extremities of the ribs as far outwards as their angles.

The Lateral Walls of the Thorax.—The two lateral walls of the thorax are formed by the twelve ribs, from the angles posteriorly to their junction with the costal cartilages in front.

THE WALL OF THE THORAX

The structures in the thoracic wall are as follow :—

Muscles.
- The external intercostals.
- The internal intercostals.
- The triangularis sterni.

Membranes.
- The anterior intercostal aponeurosis.
- The posterior intercostal aponeurosis.
- The costal parietal pleura.

Vessels.
- The superior intercostal vessels.
- The aortic intercostal vessels.
- The internal mammary vessels.

Nerves.
- The intercostal nerves.

The Intercostal Muscles.—In each intercostal space there are two intercostal muscles, which from their relative positions are termed *external* and *internal* respectively. They connect the two ribs of any given intercostal space, and whilst they fill up the entire *depth* of each space, they do not extend throughout its whole *length*, the external intercostal muscle being deficient in front, the internal behind.

The External Intercostal Muscles.—These muscles are attached above, to the lower border of the rib, from whence they pass obliquely downwards and forwards to the upper border of the rib below.

Posteriorly, the external intercostal muscles extend as far back as the tuberosities of the ribs, but in front only to the junctions of the ribs with their cartilages.

In the upper two or three spaces the muscles do not quite reach this junction, whilst in the lower two or three spaces they exceed it.

The interval, which is left between the point at which the muscles cease in front and the lateral edge of the sternum, is filled up by a thin shining membrane, *the*

anterior intercostal aponeurosis, through which will be seen the fibres of the internal intercostal muscle.

The Internal Intercostal Muscles.—These muscles are attached above, to the internal surface of a rib just above the subcostal groove, from whence the muscle extends obliquely downwards and backwards to the internal surface of the rib below, close to its upper border.

In front, these muscles extend as far forwards as the lateral margin of the sternum, but in the two lowest intercostal spaces they become continuous with the internal oblique muscle of the abdomen.

Posteriorly, the internal intercostals only extend as far as the angles of the ribs. The resulting deficiency is filled up by *the posterior intercostal aponeurosis,* which extends as far inwards as the anterior division of the superior costo-transverse ligament.

Nerve Supply of the Intercostal Muscles.—The intercostal nerves, that is, the anterior primary divisions of the first eleven dorsal nerves.

Relations of the Intercostal Muscles.—The deep surfaces of the intercostal muscles are in contact with the pleura. In front these muscles are, however, separated from the pleura by the triangularis sterni muscle; whilst behind, the posterior intercostal aponeurosis is similarly separated from the pleura by some unimportant muscles—the *subcostal* muscles.

Between the intercostal muscles, in each intercostal space, a small interval is left occupied by areolar tissue, embedded in which are the intercostal vessels and nerve, in the following order from above downwards—vein, artery, nerve.

Differences between the Intercostal Muscles.—The external intercostal muscles are attached to the borders of ribs, the internal to the surfaces of ribs.

The external intercostals are deficient in front, the internal behind.

The fibres of the external intercostals are stronger than those of the internal, are thicker behind than in front, and run downwards and forwards.

The Intercostal Nerves.—The nerves which are found in the intercostal spaces are the anterior primary divisions of the upper eleven dorsal nerves.

The dorsal nerves are twelve in number, and as the upper eleven run in the intercostal spaces they are termed the intercostal nerves. The anterior primary division of the twelfth dorsal nerve lies below the last rib, and is therefore referred to as the *last dorsal nerve*, the term "intercostal" being obviously inapplicable.

Of the eleven intercostal nerves the upper six are almost entirely confined to the thoracic wall, and are hence termed the *upper or pectoral intercostal nerves.*

The lower intercostal nerves pass from the intercostal spaces on to the abdominal wall, and are hence termed the *lower or abdominal intercostal nerves.*

Anterior primary divisions of the twelve dorsal nerves.	The upper six are termed the upper or pectoral intercostal nerves.
	The seventh to the eleventh inclusive are termed the lower or abdominal intercostal nerves.
	The twelfth is usually termed the last dorsal nerve.

The Upper or Pectoral Intercostal Nerves.—These nerves pass outwards in front of the superior costo-transverse ligaments and the posterior intercostal aponeuroses.

Piercing those aponeuroses, the nerves run next between the intercostal muscles, until, reaching a point midway between the sternum and the spines of the vertebræ, each nerve gives off its lateral cutaneous branch, and then continuing its onward course sinks into the substance of the internal intercostal muscle.

Opposite the costal cartilages each nerve pierces the internal intercostal muscle, and so comes to lie in front of the pleura, the triangularis sterni muscle, and the internal mammary artery, after which each nerve turns forwards and, piercing the internal intercostal muscle, the anterior intercostal aponeurosis, the origin of the pectoralis major, and the deep fascia, terminates in the integument of the breast as one of the anterior cutaneous nerves of the thorax.

Branches.—The branches of the upper or pectoral intercostal nerves may be classified as follows:—

Muscular branches.
Lateral cutaneous branches.
Terminal branches, or the anterior cutaneous nerves of the thorax.

Muscular Branches.—These are given off to the muscles in the intercostal spaces, to the triangularis sterni and to the serratus posticus superior, which last is a muscle of the back.

The Lateral Cutaneous Branches.—These branches arise from the intercostal nerves midway between the spine and the sternum. They pierce the external intercostal muscles, and appear in the intervals between the digitations of the serratus magnus muscle along a line placed rather behind the anterior fold of the axilla; they then divide into anterior and posterior branches which supply the skin over the lateral wall of the thorax.

As regards these lateral cutaneous branches, there are certain exceptions to be noted, as follows:—

The first intercostal nerve usually gives off no lateral cutaneous branch.

The second intercostal nerve gives off a lateral cutaneous branch, which does not divide into anterior and posterior branches, and which is not confined to the thorax. It crosses the axilla and supplies the skin of the upper arm, and is hence termed the *intercosto-humeral* nerve. It corresponds to the posterior division of an ordinary lateral cutaneous nerve.

The lateral cutaneous branch of the third intercostal nerve usually conforms to the rule, but it may occasionally cross the axilla, like the intercosto-humeral nerve.

The Terminal Branches, or the Anterior Cutaneous Nerves of the Thorax.—These nerves are the terminal branches of the intercostal nerves. They supply the skin over the anterior part of the thorax, extending, in the female, as far as the skin of the mamma.

The Lower or Abdominal Intercostal Nerves.—These nerves, on leaving the anterior ends of the intercostal spaces, pass forwards into the abdominal wall between the internal oblique and transversalis abdominis muscles, and become cutaneous nerves of the abdominal wall.

The Last Dorsal Nerve.—This nerve also passes on to the abdominal wall. Its lateral cutaneous branch is also exceptional, as it does not divide into anterior and posterior branches and is not confined to its own region. It crosses the iliac crest and supplies the skin of the buttock, and is hence usually termed the *iliac branch of the last dorsal nerve.*

The Intercostal Vessels.—In each intercostal space there are two arteries,—two running from behind forwards, the intercostal artery proper and its collateral intercostal branch; and two running from before backwards—the anterior intercostal arteries, which anastomose with the previously mentioned vessels. All these vessels are concealed by the ribs.

In the upper *two* intercostal spaces the intercostal artery proper and its collateral intercostal branch are derived from the superior intercostal artery, a branch of the subclavian. In the lower *nine* intercostal spaces they are derived from the descending thoracic aorta.

The anterior intercostal arteries in the upper six spaces are derived from the internal mammary artery, a branch of the first part of the subclavian artery; in the seventh, eighth, and ninth spaces, from the musculo-phrenic artery, one of the terminal branches of the internal mammary artery; and in the tenth and eleventh intercostal spaces, from the superior epigastric artery, the other terminal branch of the internal mammary.

In the present dissection of the thoracic wall it is not possible to follow all the points hereafter given in the description of these vessels. The description is, however, made more complete by including now certain relations which will only be satisfactorily determined at a subsequent stage of the dissection.

The Superior Intercostal Artery.—This artery arises in the neck, usually from the back of the second part of the subclavian artery, behind the scalenus anticus on the right side, and immediately internal to that muscle on the left

side, that is, from the first part of the subclavian on the left side.

The artery first rests upon the cervical pleura, passing backwards and slightly upwards, and then, turning downwards, it enters the thoracic inlet by passing in front of the neck of the first rib, between the gangliated cord of the sympathetic internally, and the anterior primary division of the first dorsal nerve externally.

The artery then supplies the first two intercostal spaces in the same manner as the aortic intercostals, to be immediately described.

The Aortic Intercostal Arteries.—These vessels are nine in number on each side. They arise from the descending thoracic aorta within the posterior mediastinum, and run outwards in the lower nine intercostal spaces. The upper aortic intercostals pass obliquely upwards to reach their respective spaces; the others pass horizontally outwards.

As the descending thoracic aorta is situated slightly to the left of the middle line, it follows that the right aortic intercostal arteries will be rather longer than those of the left side, and will have slightly different relations.

On the Right Side.—The aortic intercostal arteries successively pass outwards behind the œsophagus, the thoracic duct, the vena azygos major, the pleura, and the gangliated cord of the sympathetic.

On the Left Side.—The vessels pass outwards behind the pleura and the gangliated cord of the sympathetic only.

On both Sides.—The aortic intercostals, having thus gained the posterior extremities of the intercostal spaces, divide into two branches:—

A posterior or dorso-spinal branch.
An anterior or intercostal branch proper.

The Posterior or Dorso-Spinal Branch passes backwards on the inner side of the superior costo-transverse ligaments, accompanied by the posterior primary division of the corresponding dorsal nerve, to supply the spinal cord and the muscles of the back.

The Intercostal Branch Proper passes outwards between the two intercostal muscles. It lies in the subcostal groove of the rib immediately above it, and opposite the angle of the rib it gives off its *collateral intercostal branch.*

There are thus two arteries in each intercostal space—the intercostal artery proper above, and the collateral intercostal artery below.

Both these vessels pass forwards in the intercostal spaces and anastomose with the anterior intercostal arteries from the internal mammary artery, or with similar branches from one or other of its two terminal branches.

The intercostal arteries give off small branches which accompany the lateral cutaneous branches of the intercostal nerves; whilst minute filaments are also given off to the intercostal muscles and the ribs, and in the female to the mammary gland.

The Internal Mammary Artery.—This vessel arises from the first part of the subclavian artery. From this origin the vessel runs downwards, forwards, and inwards, behind the sternal end of the clavicle, to gain the deep surface of the first costal cartilage about a quarter of an inch from the lateral margin of the sternum. The vessel then runs vertically downwards to the sixth interspace, where it terminates by dividing into the superior epigastric and the musculo-phrenic arteries.

Relations.—In this course the internal mammary artery passes downwards behind the following structures:—

At its origin the internal mammary artery lies behind the inner end of the clavicle, and on the right side, in addition, behind the right innominate vein. It is then crossed from without inwards by the phrenic nerve, after which it runs vertically downwards behind the inner ends of the first six costal cartilages, the anterior intercostal aponeuroses, the internal intercostal muscles, and the intercostal nerves of the corresponding spaces.

Behind the vessel there is the parietal costal pleura throughout its whole extent. Above, the artery is in direct contact with this pleura, but below it is separated from it by the triangularis sterni muscle.

Two venæ comites accompany the internal mammary

artery, and unite into a single trunk at the upper part of the thorax.

Branches.—The branches of the internal mammary artery may be classified according to the direction in which they run.

Passing forwards—
    Anterior or perforating branches.
Passing backwards—
    Pericardial and mediastinal branches.
Passing inwards—
    Sternal branches.
Passing downwards—
    The arteria comes nervi phrenici.
Passing outwards—
    The anterior intercostal arteries, two in each of the upper six intercostal spaces.
Terminal Branches—
    The musculo-phrenic artery.
    The superior epigastric artery.

The Anterior or Perforating Arteries.—These minute vessels accompany the anterior cutaneous nerves. They reach the skin by passing forwards through the internal intercostal muscles, the anterior intercostal aponeuroses, the pectoralis major muscle, and the fasciæ. They turn outwards in the superficial fascia and supply the skin. In the female some of these vessels attain a large size, and supply the mamma.

Pericardial and Mediastinal Arteries.—These are very minute arterioles which pass backwards for the supply of the pericardium and the connective tissue of the mediastinum, and the thymus gland or its remains.

Sternal Branches.—Sternal branches run inwards to supply the deep surface of the sternum and the triangularis sterni muscle.

The Arteria Comes Nervi Phrenici, or the Superior Phrenic Artery.—This artery arises from the internal mammary near the origin of that vessel. It runs downwards with the phrenic nerve, between the parietal mediastinal pleura and the pericardium, to the diaphragm, the under surface of which muscle it supplies.

The Anterior Intercostal Arteries.—These vessels, two in number in each of the upper six intercostal spaces, run outwards, at first between the pleura and the internal intercostal muscles, and then between the intercostal muscles, to anastomose with the corresponding vessels from the superior intercostal artery and from the descending thoracic aorta.

The Musculo-Phrenic Artery.—This artery runs obliquely downwards and outwards, behind the costal cartilages of the false ribs. It supplies the diaphragm, and also gives off the anterior intercostal arteries in the seventh, eighth, and ninth intercostal spaces.

The Superior Epigastric Artery.—This artery, the inner of the two terminal branches of the internal mammary artery, runs downwards in the anterior abdominal wall, where it anastomoses with the deep epigastric artery from the external iliac.

The artery leaves the thorax between the sternal and costal origins of the diaphragm, behind the seventh costal cartilage.

This vessel gives off the anterior intercostal arteries in the tenth and eleventh intercostal spaces.

Anastomoses of the various Vessels in the Intercostal Spaces.—The *first and second intercostal spaces* are supplied by vessels derived from the superior intercostal artery anastomosing with the anterior intercostal branches from the internal mammary.

In *the third to the sixth spaces* inclusive the anastomosis is between the aortic intercostals and the internal mammary artery.

In *the seventh, eighth, and ninth spaces* the anastomosis is between the aortic intercostals and branches from the musculo-phrenic artery.

In *the last two intercostal spaces* the anastomosis is between the aortic intercostals and branches on the abdominal wall derived from the superior epigastric artery.

The Intercostal Veins.—These are considered with the posterior mediastinum.

The Triangularis Sterni Muscle.—This muscle arises from the deep or posterior surface of the ensiform process, and from the body of the sternum as high as the third costal

cartilage, and also from the sternal ends of the fourth, fifth, and sixth costal cartilages.

Insertion.—The fibres radiate outwards and upwards, to be inserted by distinct slips into the outer parts of the second to the sixth costal cartilages inclusive.

Nerve Supply.—The intercostal nerves.

Relations.—This muscle is the continuation upwards into the thorax of the transversalis abdominis muscle.

Its anterior surface is in contact with the sternum, the costal cartilages, and the internal mammary vessels.

Its posterior surface is in contact with the costal parietal pleura, and on the left side, in addition, with the pericardium.

THE THORACIC CAVITY

The Pleuræ.—The pleuræ are two serous sacs which enclose the lungs, and are intended to facilitate the movements of those viscera. Each pleural sac is an absolutely closed membrane, and there is no communication whatsoever between the pleural sacs of the two sides.

Between the two pleural sacs there is a narrow antero-posterior interval, which is known as the *mediastinal space.* It lodges almost all the contents of the thorax, with the exceptions of the lungs and the gangliated cords of the sympathetic.

Each of the pleural sacs consists of two parts, *visceral* and *parietal,* which are everywhere in contact with each other, save under certain pathological conditions such as pleural effusions, and which under normal conditions are lubricated by a little fluid.

That portion of the pleura which is in contact with the lung is termed visceral pleura, all the rest parietal pleura.

The Visceral Pleura.—The visceral pleura surrounds, and is in contact with, the lung throughout its whole extent except at the root of the lung, along which structure it is reflected inwards, to become continuous with the mediastinal parietal pleura. The visceral pleura further dips into the various fissures of the lung. It is thin and transparent, and is intimately bound to the lung substance by some cellular tissue known as the *subpleural connective tissue.*

The Parietal Pleura.—That portion of the pleural sac which is not in direct contact with the lung is termed parietal pleura. It lines the whole of the cavity in which the lung is contained, and to facilitate its description distinguishing terms are applied to its several portions as follows:—

The costal pleura.
The diaphragmatic pleura.
The cervical pleura.
The mediastinal pleura.

The costal pleura is that part of the parietal pleura which lines the ribs and intercostal spaces. It is the thickest part of the pleura.

In front, it lines the deep surface of the sternum, the triangularis sterni muscle, and the internal mammary artery.

Laterally, it clothes the deep surfaces of the ribs and their costal cartilages, and the internal intercostal muscles.

Posteriorly, at the vertebral extremities of the ribs, it lines the posterior intercostal aponeuroses, the intercostal vessels and nerves, the gangliated cords of the sympathetic, and the various costo-vertebral ligaments.

The costal pleura then turns forwards along the sides of the dorsal vertebræ, to become continuous with the mediastinal pleura. On the right side, as the costal pleura passes forwards it dips inwards behind the œsophagus, forming the *retro-œsophageal cul-de-sac*; on the left side, however, it passes uninterruptedly forwards to the left of the descending thoracic aorta.

The diaphragmatic pleura is that part of the parietal pleura which is in contact with the upper surface of the diaphragm. It is very thin, and intimately adherent to the muscle.

The cervical pleura is that part of the parietal pleura which ascends upwards into the neck. It projects upwards for about a half to one and a half inches above the sternal end of the clavicle, but never higher than the neck of the first rib. Resting upon it is the subclavian artery, hence in ligature of this vessel care must be taken not to injure the pleura.

The external surface of the cervical pleura is in contact with the scalenus anticus and medius muscles.

Attached to the apex of the cervical pleura there are some fibrous or muscular bands passing down to it from the transverse processes of the lower cervical vertebræ; thus the pleura is, as it were, suspended from above. These bands form what is sometimes referred to as *Sibson's* fascia. It is probably derived from the cervical fascia.

The mediastinal pleura is that part of the parietal pleura which extends from the sternum to the bodies of the dorsal vertebræ, and which forms the lateral boundary of the antero-posterior mediastinal space. Each mediastinal pleura by its outer surface bounds the cavity which lodges the lung, whilst by its inner surface it is in contact with the various structures lying in the mediastinal space.

Transverse Sections through the Pleura.—In order to appreciate the various parts of the pleura it is now necessary to study the disposition presented by the pleural layers in a series of transverse sections:—

Above the root of the lung.
Through the root of the lung.
Below the root of the lung.

Above the Root of the Lung.—If a transverse section be made through the thorax just above the lower border of the manubrium sterni, and consequently through the lower part of the fourth dorsal vertebra, the pleural sac, although a continuous membrane, will present the appearance of two concentric rings, one within the other, on each side.

The outermost ring is the parietal pleura. Commencing in front behind the sternum, the costal parietal pleura will be seen to pass round the deep surface of the thoracic parietes to the vertebræ, where, becoming continuous with the mediastinal parietal pleura, it passes as such uninterruptedly forwards to the starting-point at the back of the sternum.

The innermost ring is the visceral pleura, which passes uninterruptedly round and in contact with the lung.

Through the Root of the Lung.—If a transverse section be made through the thorax just below the sternal end of the second rib, and consequently through the upper part of the sixth dorsal vertebra, the following arrangement of the pleura will be noticed.

The right costal parietal pleura, commencing behind the sternum a little to the left of the middle line, will be seen to pass round the chest wall to the vertebræ, from whence it is continued forwards as mediastinal parietal pleura until it reaches the root of the right lung, along which it is reflected outwards to the lung as visceral pleura. Passing round the lung it reaches the anterior surface of the root, and then passes inwards until, becoming mediastinal parietal pleura once more, it passes forwards to the starting-point behind the sternum. This section demonstrates the absolute continuity of parietal and visceral pleuræ.

Below the Root of the Lung.—If a transverse section be made through the thorax just below the nipples, and consequently through the lower part of the eighth dorsal vertebra, the pleura may be traced as follows:—

Commencing as before, behind the sternum, the costal parietal pleura of the right side will be found passing round the chest wall to the vertebræ, and thence forwards as the mediastinal parietal pleura. It will be noticed that this section, in so far as the lungs are concerned, reproduces the first section, and that consequently there is no apparent reason why this mediastinal parietal pleura should not pass uninterruptedly forwards as it did in section number one; but the pleura having been reflected outwards at the root of the lung remains reflected outwards below that point, consequently the mediastinal parietal pleura will in this section pass outwards to the inner surface of the lung, and thence as visceral pleura round the lung, and then passing inwards it becomes continuous with the mediastinal parietal pleura once more, and so on to the starting-point.

These two reflected layers of the mediastinal parietal pleura are known as the *ligamentum latum pulmonis.*

The Ligamentum Latum Pulmonis.—The ligamentum latum pulmonis, or the ligament of the lung, consists of a double layer of pleura, which corresponds to the junction of parietal and visceral pleuræ; as it serves to attach the

lung to the structures in the mediastinal space, it is termed the ligament of the lung.

Dissection to expose the Ligamentum Latum Pulmonis.—The thoracic cavity having been opened, draw the lung outwards and backwards, and the ligament will then be seen passing from the inner surface of the lung, below the hilum, to the pericardium.

The Ligamentum Latum Pulmonis is a triangular sheet of pleura passing transversely inwards in the manner indicated.

The base rests upon the diaphragmatic pleura, to which it is sometimes adherent throughout.

The apex corresponds to the lower border of the root of the lung.

The external border is in contact with the inner surface of the lung, whilst the internal border is in contact with the pericardium.

The anterior and posterior surfaces look forwards and backwards respectively.

Relations of the Pleuræ to the Chest Wall.—The relations of the pleuræ to the chest wall being of the greatest practical importance, both in medicine and surgery, it is very necessary for the student to study them very attentively; and further, to utilise every opportunity of mapping them out both on the skeleton and on the living subject. The relations of the pleuræ to the chest wall differ somewhat on the two sides.

On the Right Side.—Commencing at a point half to one and a half inches above, and to the outer side of the sternal end of the right clavicle, the right pleura passes obliquely downwards and inwards, and crossing the middle line comes into contact with, and sometimes overlaps, the left pleura at the level of the second chondro-sternal articulation.

From this point downwards to the level of the fifth chondro-sternal articulation the two pleuræ are either in contact or are very frequently found overlapping each other in the middle line; below the articulation just mentioned the left pleura recedes very slightly, whilst the right pleura continues its vertical course downwards to within a quarter of an inch of the xiphi-sternal articulation, or opposite the sixth chondro-sternal articulation.

From this point the base of the pleura follows an oblique line, which passes outwards behind the seventh costal cartilage until it reaches, in the mid-axillary line, the lower border of the ninth rib, whence it turns almost horizontally inwards and, clothing the inner or vertebral third of the last rib, reaches the spinal column at the level of the upper border of the first lumbar vertebra.

From this point it passes upwards to the starting-point along the side of the vertebral column as high as the neck of the first rib.

On the Left Side.—As the diaphragm does not extend so far upwards on the left side as on the right, it follows that the left pleura will descend a little lower than the right.

Commencing at a point half to one and a half inches above and to the outer side of the sternal end of the left clavicle, the left pleura passes almost vertically downwards behind the middle line of the sternum, to the fifth chondro-sternal articulation, or very frequently as low as the sixth chondro-sternal articulation, and is thence reflected outwards and downwards to the osseous portion of the eighth rib. Reaching the mid-axillary line, it is there placed opposite the lower border of the tenth rib, and from thence ascends very slightly to reach the vertebral column at the corresponding place and in the same manner as the right pleura.

It will thus be noticed that a small portion of the manubrium sterni is not lined by pleura.

The lowest limit of the pleural sac on both sides does not extend quite down to the thoracic attachment of the diaphragm, but leaves a small portion of the circumference of this muscle in contact with the costal parietes; this small space is termed the *costo-diaphragmatic sinus.* The lowest limit of the costal pleura is bound down to the inferior angle of this space by a tendinous fascia, termed the *phrenico-pleural fascia.*

The Mediastinum.—The mediastinum, or the mediastinal space, is the central antero-posterior aperture between the two pleural sacs. Transverse sections through the thorax

readily demonstrate that the greater part of the thoracic cavity is occupied by the lungs, whilst in the mediastina are contained the numerous structures which are confined to, or which traverse, the thorax.

The mediastinal space extends through the whole depth of the thorax, from its inlet above to the diaphragm below; and from the sternum in front to the vertebral column behind. On either side it is limited by that portion of the parietal pleura which has been referred to as mediastinal pleura.

The central portion of this mediastinal space is much enlarged, in order to lodge the heart and great vessels; but both in front and behind this it is very much narrower, the two layers of mediastinal pleura being there almost in apposition.

Subdivision of the Mediastinal Space.—In order to facilitate description, the mediastinal space is divided by an imaginary line drawn from the lower border of the manubrium sterni to the lower border of the fourth dorsal vertebra, into a superior mediastinum and an inferior mediastinum, the latter being again divided into anterior, middle, and posterior mediastina by the pericardium, making in all four mediastina.

The Superior Mediastinum.—The superior mediastinum lies above the pericardium. It is bounded as follows:—

In Front.—By the manubrium sterni and the origins of the sterno-hyoid and sterno-thyroid muscles.

Behind.—By the bodies and intervertebral discs of the first four dorsal vertebræ and the origins of the longus colli muscles.

Above.—By the inlet of the thorax.

Below.—By the imaginary line drawn from the lower border of the manubrium sterni obliquely backwards and upwards to the lower border of the fourth dorsal vertebra.

Laterally.—By the mediastinal parietal pleuræ.

The principal, but by no means all, the contents of the superior mediastinum, may be artificially classified, in order from before backwards, as follows:—

Two Sets of Glands.

- The remains of the thymus gland.
- Several lymphatic glands.

Two Sets of Veins.
- The two innominate veins.
- The upper half of the superior vena cava.

Two Sets of Nerves.
- The phrenic nerves.
- The pneumogastric or vagus nerves.

Two Sets of Arteries.
- The arch of the aorta.
- The branches of the arch of the aorta, namely, the innominate, the left common carotid, and the left subclavian.

Two Tubes.
- The trachea.
- The œsophagus.

Two other Structures.
- The thoracic duct.
- The left recurrent laryngeal nerve.

The Anterior Mediastinum.—The anterior mediastinum lies in front of the pericardium. On account of the slight divergence of the two pleural sacs, it is somewhat triangular in shape. It is bounded as follows:—

In Front.—The lower part of the body of the sternum and the triangularis sterni muscle, and the sternal ends of the cartilages of the sixth and seventh ribs of the left side.

Behind.—The pericardium.

Laterally.—The mediastinal parietal pleuræ.

Contents.—Areolar tissue and the anterior mediastinal lymphatic glands.

The Middle Mediastinum.—This is the enlarged central portion of the inferior mediastinal space; it corresponds to the pericardium. Its contents are as follows:—

- The pericardium and the heart.
- The ascending aorta and its branches.
- The trunk of the pulmonary artery.
- The lower half of the superior vena cava.
- The termination of the vena azygos major.
- The roots of the lungs and the bronchial lymphatic glands.
- The phrenic nerves and their arteriæ comites.

The Posterior Mediastinum.—The posterior mediastinum lies behind the pericardium, between it and the vertebral column. It is intermediate in size between the smaller anterior mediastinum and the larger middle mediastinum, and contains the following structures:—

The descending thoracic aorta.
The œsophagus.
The pneumogastric nerves.
The azygos veins.
The thoracic duct.
The posterior mediastinal lymphatics.

The Lungs.—The lungs, two in number, occupy the greater part of the thoracic cavity, and together constitute the essential organs of the respiratory apparatus.

In the fœtus, before birth, the lungs are relatively small, but after respiration has commenced they become very much increased in size. In the first case the lungs form only $\frac{1}{53}$rd of the total body weight; in the second, $\frac{1}{37}$th.

In the adult each lung is irregularly pyramidal in shape, and presents for examination the following parts:—

A base.
An apex.
An anterior border.
A posterior border.
An external surface.
An internal surface.

The Base.—The base of each lung is large and concave, and rests upon the dome of the diaphragm, to which it is exactly moulded. On each side it looks downwards, forwards, and inwards.

The base of the right lung, on account of the increased upward projection of the liver on that side, is more concave than that of the left side, and is only separated from the right lobe of the liver by the diaphragm.

The base of the left lung is similarly separated from the left lobe of the liver, the stomach, and the spleen.

Posteriorly and laterally, the base of the lung is bounded by a thin, sharp margin, which extends downwards into, but does not entirely fill up, the small, narrow pleural recess which exists between the costal and diaphragmatic pleuræ. Below this margin of the base of the lung there are, therefore, two layers of *parietal* pleura in direct contact.

The Apex.—The apex of the lung is somewhat blunted and rounded. It projects upwards into the neck for about one inch above the anterior extremity of the first rib. It is covered by the cervical pleura, by means of which it is alone separated from the first rib, and the subclavian, superior intercostal, and internal mammary arteries. The apex of the right lung usually extends a little higher up in the neck than that of the left lung.

The Anterior Border.—The anterior border is thin, sharp, and slightly sinuous, overlapping the pericardium. On the right side it passes almost vertically downwards to the level of the fifth or sixth chondro-sternal articulation; but on the left side it is distinctly notched, thus constituting the *incisura cardiaca.*

The Posterior Border.—The posterior border of the lung differs from the anterior in being blunted and rounded, and also in its greater length, the posterior border being half as long again as the anterior.

In the recent condition the posterior border of the lung fits into and occupies the costo-vertebral groove on either side of the vertebral column. This border is in apposition successively, from within outwards, with the lateral part of the bodies of the dorsal vertebræ, the costo-vertebral articulations, the posterior extremities of the ribs and the corresponding intercostal spaces, and with the gangliated cord of the sympathetic resting upon the heads of the ribs.

The External Surface.—The external surface of the lung is smooth, convex, and free. It is everywhere in contact with the chest wall, and presents various slight grooves corresponding to the various ribs. It is further marked by certain fissures, to be presently described.

The Internal Surface.—The internal or mediastinal surface is concave and smooth. On account of the greater projection of the heart to the left side, the concavity is greater on the inner surface of the left lung than on the right.

On this surface, midway between the apex and base of the lung, and at the junction of the anterior three-fourths with the posterior fourth, is situated the *hilum* of the lung. The hilum is the fissure by means of which the bronchi and great vessels enter or leave the lung; together they constitute the *root* of the lung. The hilum is about three inches long.

Division of the Lungs into Lobes.—The right lung is divided into three lobes by means of the great oblique and horizontal fissures; and the left lung into two lobes by a single fissure, the great oblique fissure.

Fissures of the Right Lung.—*The Great Oblique Fissure*, as seen from without, commences in the posterior border of the lung about two and a quarter inches below the apex; it then runs forwards and downwards, somewhat more vertically than on the left side, to end in the base of the lung about two inches external to its junction with the anterior border. If the internal surface of the lung be examined, the fissure will be seen to pass to the hilum of the lung, and as the fissure is a very deep one it follows that it almost completely cuts the lung into two parts.

Its position on the living subject may be roughly indicated by a line drawn from the spine of the second dorsal vertebra to the sixth rib in the mammary line.

The Horizontal Fissure is given off from the great oblique fissure a little below its commencement, and runs almost horizontally inwards to join the anterior border of the lung at the level of the fourth chondro-sternal articulation. It then passes on the internal surface of the lung to the hilum.

Lobes of the Right Lung.—By means of the two foregoing fissures the right lung is divided into three lobes—superior, middle, and inferior.

The Superior Lobe of the Right Lung lies above the posterior part of the great oblique fissure and the horizontal fissure. It comprises the upper part of the posterior border, the apex, and the greater part of the anterior border of the lung.

The Middle Lobe of the Right Lung lies between the horizontal fissure and the great oblique fissure. It comprises the lower part of the anterior border and part of the base of the lung. This lobe is the smallest of the three.

The Inferior Lobe of the Right Lung lies below the great oblique fissure. It comprises the greater part of the posterior border and base of the lung. It is the largest of the three lobes.

Fissure of the Left Lung.—*The Great Oblique Fissure,* the only one in the left lung, commences on the inner surface of that viscus near the upper and posterior part of the hilum; from thence it runs upwards and backwards to the posterior border, which it reaches about the level of the fourth dorsal vertebra, or about three inches below the apex of the lung. Running downwards and forwards over the external surface of the lung, it reaches the base very near its junction with the anterior border, and terminates on the inner surface at the lower part of the hilum.

Lobes of the Left Lung.—The foregoing fissure divides the left lung into two lobes, superior and inferior.

The Superior Lobe, the smaller of the two, lies above the fissure, and is conical in shape. It comprises the apex, the whole of the anterior border, and the greater part of the concave inner surface.

The Inferior Lobe, the larger of the two, lies below the great oblique fissure, and is somewhat quadrilateral in shape. It comprises almost the whole of the posterior border and the greater part of the diaphragmatic surface of the lung.

Relations of the Lungs to the Chest Wall.—The relations of the lungs to the thoracic parietes reproduce to a very large extent the corresponding relations of the pleuræ, except as regards their bases.

The lungs do not extend quite so far down as the pleuræ, consequently their lowest limit will be indicated on the living subject by a line, with a slight downward convexity, drawn from the sixth chondro-sternal articulation to the lowest part of the neck of the eleventh rib.

For practical purposes the lowest part of the pleuræ may be ascertained by mapping out the bases of the lungs in the manner indicated, and then exceeding this line by about three-quarters of an inch.

Vascular Supply of the Lungs.—The arterial supply is derived from the bronchial arteries. These vessels vary in number from one to three for each lung, and are derived from either the descending thoracic aorta or from an intercostal artery.

The bronchial veins emerge from the root of each lung as a single vessel, which terminates, on the right side in the vena azygos major, and on the left side in the vena azygos minor superior.

Nerves of the Lungs.—From the anterior and posterior pulmonary plexuses, and therefore indirectly from the vagi and sympathetic nerves.

Differences between the two Lungs.—These are as follows:—

The left lung is longer, lower, and lighter than the right.

The inner surface of the left lung is more concave, its base is less so than the corresponding surfaces of the right lung.

The left lung has one fissure, and therefore only two lobes, whilst the right lung has two fissures and three lobes.

The intrapulmonary relations of the roots of the two lungs differ on the two sides, as do also their relations to surrounding structures.

The anterior border of the left lung is notched, forming the cardiaca incisura, whilst the posterior border may be grooved for the lodgment of the descending thoracic aorta.

The Root of the Lung.—The root of the lung comprises the various structures which enter or leave the lung at the hilum on its internal concave surface. The various structures forming the root are bound together by areolar tissue and are surrounded by pleura.

Before examining the structures in the root of the lung itself, its relations to surrounding parts must first be studied. These relations differ slightly on the two sides, and are as follows:—

On the Right Side.—*In front.*—The superior vena cava and part of the right auricle. The phrenic nerve with the arteria comes nervi phrenici, and the anterior pulmonary plexus.

Behind, the vagus nerve, breaking up into the posterior pulmonary plexus.

Above, the vena azygos major, arching forwards above the root of the lung, to terminate in the superior vena cava.

Below, the ligamentum latum pulmonis.

On the Left Side.—*In front*, the phrenic nerve, with the arteria comes nervi phrenici, and the anterior pulmonary plexus.

Behind, the vagus nerve, breaking up into the posterior pulmonary plexus, and the descending thoracic aorta.

Above, the arch of the aorta.

Below, the ligamentum latum pulmonis.

Constituent Parts of the Root of the Lung.—The structures which form the root of the lung are as follows:—

The pulmonary veins.
The pulmonary artery.
The bronchus.
The bronchial arteries and veins.
The pulmonary nerves.
The pulmonary lymphatic vessels.

All these structures are bound together by areolar tissue, and the entire root is invested by pleura.

The *pulmonary veins, artery, and bronchus* differ in their relations to one another on the two sides.

On *both sides*, from before backwards, the order of the structures is the same,—veins, artery, bronchus. The bronchial vessels and the pulmonary nerves and lymphatics lie behind them at the most posterior part of the root.

On the *right side* the order of the three principal structures from above downwards is bronchus, artery, veins.

On the *left side* the order from above downwards is artery, bronchus, veins.

This difference in the order of the three principal structures from above downwards on the two sides is simply due to the fact that the right lung possesses three lobes and the left lung only two. The right bronchus gives off, close to its origin, a branch which proceeds almost horizontally outwards to the superior lobe of the right lung. It lies above the level of the pulmonary artery, and is therefore termed

the *eparterial bronchus.* The other branches of the right bronchus, and all those from the left bronchus, lie below the level of the main trunk of the pulmonary artery, and are consequently termed the *hyparterial bronchi.*

The absence of the eparterial bronchus on the left side and its presence on the right side explains, then, this difference in the order, from above downwards, on the two sides, of the three principal structures in the root of the lung.

The *bronchial arteries* are the proper nutrient vessels of the lungs. They are branches of the descending thoracic aorta, and are usually two in number on the left side, but only one on the right. They usually lie at the back of the bronchus, and follow it into the lung.

The *bronchial veins* accompany their arteries. That from the right lung terminates in the vena azygos major near its termination in the superior vena cava. The left bronchial vein terminates in the vena azygos minor superior.

The bronchial veins only return a portion of the arterial blood conveyed to the lungs by the bronchial arteries. The venous blood from the smaller bronchial tubes, as well as that from some of the larger ones, passes into the pulmonary veins.

The *pulmonary nerves* are derived from both the anterior and posterior pulmonary plexuses.

The *anterior pulmonary plexus* lies in front of the root of the lung. It is formed by minute filaments from the following sources :—

The vagus nerve.
The sympathetic nerves on the pulmonary artery.
The deep cardiac plexus.

The anterior pulmonary plexus on the left side is slightly larger than that on the right, because it receives, in addition to the branches just mentioned, minute filaments from the superficial cardiac plexus.

The *posterior pulmonary plexus* lies behind the root of the lung. Unlike the anterior plexus, it is formed almost entirely by the vagus nerve, which, as it descends behind the root of the lung, breaks up into a flattened network, and so forms the posterior pulmonary plexus. This plexus is joined, in addition, by some minute filaments from the third and fourth ganglia of the thoracic portion of the gangliated cord of the sympathetic.

The posterior pulmonary plexuses of the two sides are connected together by some transverse fibres which run across the front of the œsophagus.

Both the anterior and posterior pulmonary plexuses give off numerous filaments which run inwards to the lungs along the bronchi.

The Phrenic Nerves.—The phrenic nerves arise in the neck, mainly from the anterior primary division of the fourth cervical nerve, with additional filaments from either the third or the fifth nerves. They descend through the superior and middle mediastina to the diaphragm, which they supply, and consequently they are the great motor nerves of respiration. Each phrenic nerve also gives off some minute filaments to the pleura and pericardium.

The Right Phrenic Nerve.—The right phrenic nerve enters the thorax between the right subclavian artery and vein, crossing the internal mammary artery from without inwards and backwards. It then descends nearly vertically, first lying between the right innominate vein and the superior vena cava on its inner side, and the mediastinal parietal pleura on its outer side. It then passes in front of the root of the right lung, and next lies between the pericardium on its inner side and the mediastinal parietal pleura on its outer side, which relations it maintains for the rest of its course.

The Left Phrenic Nerve.—The left phrenic nerve is somewhat longer than the right, for two reasons—firstly, on account of the greater projection of the heart to the left side; and, secondly, because the diaphragm is lower on the left side.

The left phrenic nerve enters the thorax between the left innominate vein and the left subclavian artery. It crosses in front of the left pneumogastric nerve, and downwards on the left side of the arch of the aorta, after which it pursues the rest of its course between the pericardium and the mediastinal parietal pleura.

To expose the phrenic nerves after the thoracic cavity is

opened, all that is necessary is to separate the pleura from the pericardium.

Each phrenic nerve is accompanied by a small artery—the arteria comes nervi phrenici, a branch from the internal mammary.

Remains of the Thymus Gland.—In the *adult* there is sometimes to be seen, just above the arch of the aorta and immediately in front of the innominate and left common carotid arteries, some discoloured condensed tissue. This represents the remains of the thymus gland of the infant.

In the *infant* the thymus gland attains its greatest size at about the end of the second year, after which it gradually atrophies and finally becomes reduced to the merest vestige.

At about the end of the second year of life the thymus gland is a narrow, elongated structure, composed of two nearly symmetrical lateral lobes, with an occasional intermediate lobe, and is situated partly in the thorax and partly in the lower part of the neck.

Above, the thymus gland extends upwards in front of the trachea almost to the thyroid body, and is overlapped by the sterno-hyoid and sterno-thyroid muscles.

Below, it extends downwards through the superior and anterior mediastina, behind the sternum and in front of the great thoracic vessels and pericardium, to the level of the fourth chondro-sternal articulations.

The Innominate Veins.—The innominate veins are two in number, right and left. Both the innominate veins are formed behind the inner ends of their respective clavicles by the junction of the internal jugular vein with the subclavian vein. They terminate behind the first right chondro-sternal articulation by uniting together to form the superior vena cava. Neither of these veins has any valves.

The Right Innominate Vein.—This vein is one inch in length, and descends almost vertically. Immediately to its *right* side there are the right mediastinal parietal pleura and lung, from which it is separated by the right phrenic nerve. To its *left* side are the commencement of the right subclavian artery and the innominate artery.

Tributaries.—The vertebral, inferior thyroid, and internal mammary veins, and occasionally the highest intercostal vein, all of the right side.

The right lymphatic duct terminates in the outer angle of junction of the right internal jugular and subclavian veins.

The Left Innominate Vein.—This vein is three inches in length, and passes obliquely downwards and to the right. *In front*, the vein is separated from the manubrium sterni by the origins of the sterno-hyoid and sterno-thyroid muscles and by the remains of the thymus gland. *Behind* the vein are the three branches of the aorta, namely, the innominate, left common carotid, and left subclavian arteries, and the phrenic and pneumogastric nerves of the left side. Immediately *below* the vein is the arch of the aorta itself.

Tributaries.—The vertebral, inferior thyroid, and internal mammary veins of the left side, and, in addition, the small thymic, mediastinal, and pericardial veins, and the superior intercostal vein of the left side. Occasionally the highest intercostal vein of the left side terminates in the left innominate.

The thoracic duct terminates in the outer angle of junction of the left internal jugular and subclavian veins.

The Superior Vena Cava.—This vein is formed behind the first right chondro-sternal articulation by the junction of the right and left innominate veins. It descends almost vertically for three inches, and terminates behind the upper border of the third right costal cartilage by opening into the upper angle of the right auricle. It has no valves.

(*a*) The *upper part* of the superior vena cava lies in the superior mediastinum, and is not covered by pericardium. *In front* of this part of the vein are the pleura and the right lateral border of the sternum. Behind is the commencement of the right bronchus. To the *outer* side there are the mediastinal parietal pleura, the lung, and the phrenic nerve of the right side. To the *inner* side, the innominate artery.

(*b*) The *lower part* of the superior vena cava lies in the middle mediastinum, and with the exception of its posterior surface, is everywhere surrounded by serous pericardium. Its *posterior* part is in direct contact with the right pulmonary artery and the upper right pulmonary vein. To its *outer* side

are the mediastinal parietal pleura and lung of the right side, and to its *inner* side, the ascending aorta.

Tributaries.—The vena azygos major, pericardial and mediastinal veins. The vena azygos major arches forwards above the root of the right lung, to terminate in the superior vena cava just above the pericardium.

The Pericardium.—The pericardium is a fibro-serous sac loosely enveloping the heart and the origins of the great vessels which arise from that organ. It lies in the middle mediastinum, and is composed of two distinct portions:—

An external fibrous layer, the fibrous pericardium.
An internal serous layer, the serous pericardium.

The Fibrous Pericardium.—The fibrous pericardium has the form of a hollow cone with its base below and the apex above.

The base rests upon the central tendon of the diaphragm, to the margins of which it is intimately adherent.

The apex is directed upwards towards the great vessels, which it surrounds, and with the external coats of which it becomes inseparably blended.

With the exception of the inferior vena cava, all the great vessels of the heart receive prolongations from the fibrous pericardium. The inferior vena cava receives no covering from the fibrous pericardium, because the vein pierces the central tendon of the diaphragm, and the fibrous pericardium is attached to the margins of that tendon without extending inwards on its superior surface. It cannot, therefore, give a covering to the inferior vena cava.

The Serous Pericardium.—The serous pericardium lines the superior surface of the central tendon of the diaphragm and the internal or deep surface of the fibrous pericardium, from whence it is reflected above, in the region of the great vessels, on to the heart. It has therefore a parietal and a visceral layer.

The Parietal Layer.—The parietal layer of the serous pericardium lines, and is inseparably blended with the fibrous pericardium, from whence it passes on to the superior surface of the central tendon of the diaphragm.

Above, at the apex of the fibrous pericardium, the parietal serous pericardium is reflected on to the great vessels of the heart, from one to one and a half inches above its base. In this way the parietal serous pericardium becomes directly continuous with the visceral serous pericardium.

The Visceral Layer.—The visceral layer of the serous pericardium lines the external surface of the heart, and is therefore usually termed the *epicardium.* It is continuous above with the parietal serous pericardium, and is thence prolonged downwards over the great vessels of the heart, the auricles and their appendices, the ventricles and the apex of the heart.

The aorta and the pulmonary artery are surrounded by the epicardium in such a way that there is a common tubular sheath for both vessels. It is therefore possible, after the pericardial sac has been opened, to pass the finger between these vessels and the auricles, the passage through which the finger passes being known as the *great transverse sinus.* The remaining vessels at the base of the heart are only partially invested by the serous pericardium.

On separating the left pulmonary artery from the uppermost left pulmonary vein a small triangular fold of epicardium is seen. This is the *vestigial fold of Marshall.* It is a reduplication of the epicardium, and between its two layers are the remains of the embryonic duct of Cuvier, or the left superior vena cava of the embryo.

The vena azygos major enters the superior vena cava above the pericardium, and does not therefore pierce the pericardium.

Relations of the Pericardium.—*Below,* the pericardium rests upon the central tendon of the diaphragm and upon the adjacent muscular portion to a very slight extent, but rather more so upon the left side than the right. The diaphragm separates the pericardium from the superior surface of the liver and from the stomach.

Above, the fibrous pericardium becomes lost on the great vessels of the heart. It encloses and conceals from view the lower part of the superior vena cava, the ascending aorta, and the trunk of the pulmonary artery.

In front, the pericardium forms the posterior boundary of

the anterior mediastinum. It is separated from the sternum and costal cartilages by the two pleural sacs, the thin anterior margins of the two lungs, and by the contents of the anterior mediastinum. It is usual to describe a small portion of the pericardium as being uncovered by pleura, on account of the left pleura receding from the middle line of the body. As this recession of the left pleura is not nearly so great as usually described, it is much more probable that in many instances there is no part of the pericardium uncovered, anteriorly, by pleura; and in any case, even though the pericardium be uncovered by pleura, the area is very much smaller than usually described. In tapping the pericardium, surgically, the needle will therefore pass through the pleura.

Behind, the pericardium forms the anterior boundary of the posterior mediastinum, and is an immediate anterior relation of the œsophagus and descending thoracic aorta.

Laterally, the pericardium is moulded into the concave internal surfaces of the two lungs, from which it is separated by the phrenic nerve and the accompanying arteria comes nervi phrenici, and by the mediastinal and visceral pleuræ, and the ligamentum latum pulmonis.

The Cardiac or Coronary Arteries.—The arteries which supply the substance of the heart are two in number—right and left coronary arteries. They both arise from the ascending aorta.

The Right Coronary Artery.—This vessel arises from the ascending aorta within the anterior sinus of Valsalva. It passes forwards between the pulmonary artery and the right auricular appendix, and then runs obliquely round the heart in the auriculo-ventricular groove to anastomose with the left coronary artery.

Branches.—The right coronary artery supplies the right side of the heart as follows:—

Unnamed branches are given off to the ascending aorta, the pulmonary artery, the right auricle, and the right ventricle.

An infundibular branch is distributed to the front of the infundibulum or the conus arteriosus of the right ventricle.

A marginal branch runs along the margo acutus or lower lateral margin of the right ventricle towards the apex of the heart, and supplies both surfaces of the right ventricle.

A posterior interventricular branch runs in the corresponding groove to the apex of the heart. It supplies the postero-inferior surfaces of both ventricles.

The Left Coronary Artery.—This vessel arises from the ascending aorta within the left posterior sinus of Valsalva. It makes its appearance between the pulmonary artery and the left auricular appendix, and then runs obliquely round the margo obtusus or upper lateral margin of the heart in the left auriculo-ventricular groove, to anastomose with the right coronary artery.

The two coronary arteries thus form an arterial ring which runs round the heart in the auriculo-ventricular groove.

Branches.—The left coronary artery supplies the left side of the heart as follows:—

Unnamed branches are given off to the ascending aorta, the pulmonary artery, and the left auricle.

An anterior interventricular branch runs in the corresponding groove to the apex of the heart, and supplies the front of both ventricles.

A marginal branch runs along the margo obtusus or upper lateral margin of the left ventricle towards the apex of the heart, and supplies both surfaces of the left ventricle.

The Veins of the Heart.—The veins of the heart differ somewhat from the arteries, the venous blood being returned to the right auricle by means of—

The great cardiac vein and its continuation, the coronary sinus.
Accessory cardiac veins.

The Great Cardiac Vein and the Coronary Sinus.—*The great cardiac vein* commences near the apex of the heart, and then runs along the anterior interventricular groove to the auriculo-ventricular groove, when it changes its direction, passing to the left in the auriculo-ventricular groove, round the margo obtusus or upper lateral margin of the heart, until it reaches the postero-inferior surface, where it terminates by becoming directly continuous with the coronary sinus.

The coronary sinus is the direct continuation of the great

cardiac vein. It lies in the left auriculo-ventricular groove at the posterior part of the heart, and after a course of about one inch it terminates in the cavity of the right auricle, just in front of the inferior vena cava, its orifice being guarded by the valve of Thebesius.

Developmentally, the coronary sinus has nothing to do with the great cardiac vein. It is the persistent terminal portion of the left superior vena cava of the fœtus, hence the necessity of describing the apparently one continuous structure of the adult heart—the great cardiac vein and the coronary sinus—in two parts.

Tributaries.—The tributaries of the coronary sinus are as follows:—

The right or small coronary vein.
The middle cardiac vein.
The posterior cardiac veins.
The oblique vein of Marshall.

The Right or Small Coronary Vein.—This small vein drains the back part of the right auricle and ventricle. It passes transversely in the right auriculo-ventricular groove, to terminate in the right extremity of the coronary sinus.

The Middle Cardiac Vein.—This vein drains the back part of both ventricles. It commences at the apex of the heart and runs along the posterior interventricular groove, to terminate in the right extremity of the coronary sinus.

The Posterior Cardiac Veins.—These small veins, some three or four in number, drain the back part of the left ventricle. They terminate in the coronary sinus near its commencement.

The Oblique Vein of Marshall.—This vein runs obliquely downwards and inwards along the posterior surface of the left auricle, to terminate in the left extremity of the coronary sinus. Its functional activity is often small, but the vein is important, as it represents another part of the left superior vena cava of the embryo.

The Accessory Cardiac Veins.—Under this head are included those small veins which open directly into the cavity of the right auricle without first opening into the coronary sinus.

The accessory cardiac veins are as follows:—

The anterior cardiac veins.
The venæ minimæ cordis.

The Anterior Cardiac Veins.—These small veins drain the antero-superior surfaces of the two ventricles. They terminate in the right auricle, just above the right auriculo-ventricular groove.

The Venæ Minimæ Cordis.—These minute veins are situated in the muscular substance of the heart. They open into the right auricle upon and near the inter-auricular septum, their orifices producing some of the minute foramina of Thebesius.

The Heart.—The heart, surrounded by its pericardial sac, occupies the middle mediastinum. It lies between the two lungs, and is separated from the abdominal cavity by the diaphragm.

It is very important to realise that the heart lies almost horizontally in the chest cavity, in such a way that its long axis is almost parallel with the ground. The auriculo-ventricular groove cuts the long axis of the heart at right angles, and is therefore almost vertical in position; it may be mapped out on the living subject by a line drawn from the third left chondro-sternal articulation downwards and slightly to the right, to the sixth right chondro-sternal articulation. A transverse section through the eighth dorsal vertebra cuts all four chambers of the heart simultaneously.

The heart projects much more to the left side than to the right; one-third of the organ lies to the right side of the mesial plane of the body, and two-thirds to the left of that plane.

Form of the Heart.—During life the form and position of the heart change slightly with each pulsation, and further, its shape varies with the distension or otherwise of the auricles and ventricles. It is therefore a matter of extreme difficulty to give an accurate description of the external configuration of the heart. The description which follows is probably only an approximation to the truth. It is further expedient to use the terms "right" and "left" in connection with the heart as seldom as possible, as such terms are always confus-

ing and often inaccurate. Through long-established custom these terms are still retained for the differentiation of the various chambers of the heart, though even here the term "left," for example, as applied to the left auricle, is quite erroneous, as that cavity lies *behind* the so-called right auricle.

The heart may be said to present for examination a base, an apex, an antero-superior surface, a postero-inferior surface, a lower border or margo acutus, and an upper border or margo obtusus.

The Base.—This is directed upwards, backwards, and to the right. It is placed opposite the fifth, sixth, seventh, and eighth dorsal vertebræ. The great blood vessels are attached to the base of the heart.

The Apex.—This points to the left, and slightly downwards and forwards. It is formed entirely by the left ventricle, and the apex beat may be felt in the fifth left intercostal space one and a half inches below the nipple, and three and a half inches to the left of the middle line of the body.

The Antero-Superior Surface.—This surface looks upwards and forwards towards the sternum and costal cartilages, from which it is separated by the pericardium, the pleura, and, to a large extent, by the lungs.

That part of this surface of the heart which is uncovered by the lungs is termed the area of the *superficial cardiac dulness.* It may be mapped out by taking three points and joining these together by means of three lines. The three points to be taken are—a point just internal to the apex beat; a second point, in the middle line of the sternum opposite the fourth costal cartilage; and a third point, in the middle line of the sternum opposite the xiphi-sternal articulation.

There is only a small part, if any, of this surface of the heart which is uncovered by pleura.

The Posterior-Inferior Surface.—The greater portion of this surface rests upon the diaphragm, from which it is only separated by parietal serous pericardium. A smaller portion looks backwards towards the vertebral column.

The diaphragm and pericardium alone separate the greater portion of this surface of the heart from the liver and the fundus of the stomach.

The Upper Border or the Margo Obtusus.—This border is short, thick, and rounded; and is formed almost entirely by the left ventricle.

The Lower Border or the Margo Acutus.—This border is thin and sharp, and is formed chiefly by the right ventricle. Its general direction is from right to left and slightly forwards.

General Conformation of the Heart.—The heart consists of so-called right and left cavities, completely separated from one another by septa. The former constitutes the venous heart, and the latter the arterial heart. Each of these cavities is again divided into two, making in all four chambers within the heart. The two basal chambers are termed "auricles"; the two apical chambers are termed "ventricles." These are differentiated from one another by the use of the somewhat misleading terms "right" and "left."

On the external surface of the heart the differentiation between its four chambers is quite clearly indicated by certain grooves; thus the basal auricles are separated from the apical ventricles by the auriculo-ventricular grooves and from one another by the inter-auricular grooves, whilst the ventricles are separated from one another by the interventricular grooves.

The *auriculo-ventricular groove* is a deep furrow which encircles the heart at right angles to its long axis. It is situated rather nearer the base than the apex, and separates the auricles from the ventricles. It is only interrupted in front by the pulmonary artery. That portion of the groove which separates the right auricle from the right ventricle is usually termed the *right auriculo-ventricular groove*, whilst that portion which separates the left auricle from the left ventricle is termed the *left auriculo-ventricular groove.*

The *inter-auricular groove* is but faintly marked. It is best seen behind, where it forms a shallow depression which passes from the junction of the right and left auriculo-ventricular grooves to the base of the heart. This groove corresponds to the attachments of the inter-auricular septum, which separates the cavities of the right and left auricles.

The *interventricular grooves* correspond externally to the attachments of the interventricular septum, which separates the cavities of the right and left ventricles.

That portion of the interventricular groove which is found on the antero-superior surface of the heart is termed the *anterior interventricular groove*; that portion which is found on the postero-inferior surface of the heart is termed the *posterior interventricular groove.*

The *anterior interventricular groove* commences at the auriculo-ventricular groove immediately to the left of the pulmonary artery. It terminates in the margo acutus immediately to the right of the apex of the heart. This groove lies much nearer the margo obtusus than the margo acutus.

The *posterior interventricular groove* commences at the junction of the right and left auriculo-ventricular grooves, almost opposite the termination of the coronary sinus. It terminates in the margo acutus immediately to the right of the apex of the heart. This groove lies much nearer the margo acutus than the margo obtusus.

The External Surfaces of the Auricles.—The walls of both auricles are thin and flaccid. They are situated chiefly at the back part of the heart, but each auricle sends forwards a narrow process, which is termed the *auricular appendix.*

The *right auricle* occupies the right and anterior portion of the base of the heart. The superior and inferior venæ cavæ open into its upper and lower angles respectively; and its auricular appendix passes from its upper angle, in front of the ascending aorta, to come into contact with the trunk of the pulmonary artery.

On the right lateral margin of the right auricle there is a faint groove, only visible when the auricle is distended, and which runs from the front of the superior vena cava to the right side of the inferior vena cava. This groove is the *sulcus terminalis* of His. It corresponds to the *crista terminalis* of His in the interior of the auricle.

The *left auricle* occupies the left and posterior part of the base of the heart. It lies almost entirely behind the right auricle, and the only portion of the left auricle visible on the antero-superior surface of the heart is the tip of its auricular appendix, which is situated immediately to the left of the trunk of the pulmonary artery.

As seen from behind, the left auricle is somewhat oblong, with the long axis running transversely. On either side it is joined by the pulmonary veins. Resting upon it are the right and left branches of the pulmonary artery, and arching over these structures from before backwards is the arch of the aorta.

The External Surfaces of the Ventricles.—The walls of both ventricles are thick and fleshy. They are situated at the apical portion of the heart, and are very distinctly conical in shape. Their bases coincide with the auricles.

The *right ventricle* forms two-thirds of the ventricular portion of the antero-superior surface of the heart, the greater part of the margo acutus, and one-third of the ventricular portion of the postero-inferior surface of the heart. It does not extend to the apex of the heart, but stops on the margo acutus a little to the right side of the true cardiac apex.

As seen from before, the right ventricle is triangular in outline; the base lies to the right, and is formed by the right auriculo-ventricular groove; the apex is on the margo acutus, as just stated; the upper boundary is formed by the anterior interventricular groove, and the lower boundary by the margo acutus.

The upper angle of the ventricle is prolonged upwards to the origin of the pulmonary artery, in the form of a cone which receives the name of the *conus arteriosus*, or the *infundibulum.*

The *left ventricle* forms two-thirds of the ventricular portion of the postero-inferior surface of the heart, the greater part of the margo obtusus, the whole of the true cardiac apex, a very small part of the margo acutus, and one-third of the ventricular portion of the antero-superior surface of the heart.

The Cavity of the Right Auricle.—The cavity of the right auricle is somewhat irregularly triangular in outline, presenting for examination a base, an apex, an anterior wall, and a posterior or inter-auricular wall.

The Base.—The base of the right auricle corresponds

to a line drawn between the superior and inferior vena cavæ. Just in front of this line there is a vertical muscular ridge,—*the crista terminalis of His.* On the outer surface of the auricle the crista terminalis produces a corresponding groove, *the sulcus terminalis.* This extends from the front of the superior vena cava to the right side of the inferior vena cava.

The *crista terminalis of His* divides the interior of the right auricle into a posterior smooth portion, termed the *atrium or the sinus venosus,* and an anterior appendicular portion covered with vertical muscular ridges, named, from their supposed resemblance to the teeth of a comb, *the musculi pectinati.* These terminate on the crista terminalis.

This division of the cavity of the right auricle by means of the crista terminalis is of some importance, as it serves to differentiate that portion of the auricle—the atrium—which was developed from the dilated ends of the venous trunks (the saccus reuniens of the embryo), from the roughened portion developed from the primitive auricle.

That portion of the cavity of the right auricle which lies immediately in front of the crista terminalis is ridged by the musculi pectinati, but with this exception the remainder of the cavity of the auricle proper, the atrium, is smooth and devoid of such muscular prominences.

The musculi pectinati are found, then, in the auricular appendix, and that portion of the cavity of the auricle proper which lies immediately in front of the crista terminalis.

Just below the termination of the superior vena cava there is a small tubercle situated on the base of the auricle, termed the *tubercle of Lower.* This is usually destroyed on opening the auricle, and is better marked in some of the lower animals than in man.

The Apex.—The apex is the most dependent part of the right auricle. It corresponds to the auriculo-ventricular orifice.

The Anterior Wall.—The anterior wall of the right auricle is thin and loose, and near its upper part there is an opening into the auricular appendix. This will usually admit the tip of the little finger. The interior of the appendix is roughened by the musculi pectinati, which, running parallel with one another, terminate on the crista terminalis. In the intervals between the musculi pectinati the wall of the auricle is very thin.

The Posterior or Inter-auricular Wall.—The posterior wall constitutes the inter-auricular septum, and presents for examination the following objects :—

The fossa ovalis.
The annulus ovalis.
The termination of the coronary sinus.
The valve of Thebesius.
The foramina of Thebesius.

The Fossa Ovalis.—Almost in the centre of the inter-auricular wall there is a depression, the fossa ovalis. This is the thinnest part of the posterior wall, and is the remains of an actual passage which existed in the fœtal heart between the two auricles, and which was then termed the foramen ovale.

The Annulus Ovalis.—This is a prominent ridge which surrounds the fossa ovalis above and at the sides, but not below. By its left extremity this annulus ovalis frequently becomes continuous with the remains of the valve found at the inferior vena cava,—the Eustachian valve.

The Termination of the Coronary Sinus.—Below the fossa ovalis, and between the inferior vena cava and the auriculo-ventricular opening, is the termination of the coronary sinus, guarded by the valve of Thebesius.

The Valve of Thebesius.—This is a small semilunar and incomplete valve found at the orifice of the coronary sinus. It is sometimes reticulated.

The Foramina of Thebesius.—These are some minute depressions scattered indiscriminately over the posterior wall of the auricle. Some of these are blind cul-de-sacs, others are the terminations of the venæ minimæ cordis.

Apertures of the Right Auricle.—These are as follows :—

The superior vena cava.
The inferior vena cava.
The auriculo-ventricular opening.
The coronary sinus.
The foramina of Thebesius.

The Superior Vena Cava.—The opening of the superior vena cava is situated at the upper angle of the auricle, close to the inter-auricular septum. It looks slightly forwards, and is the only one of the larger apertures of the right auricle which does not possess a valve.

The Inferior Vena Cava.—The opening of the inferior vena cava is situated at the lower angle. It is directed upwards and inwards, and in the adult there is a valvular remnant, the *Eustachian valve.* This valve, which is much better marked in the fœtal heart, is somewhat crescentic in outline, and is frequently reticulated. In the fœtal heart it serves to direct the purified or placental blood from the inferior vena cava, across the cavity of the right auricle, through the foramen ovale, into the left auricle.

The Cavity of the Right Ventricle.—This is somewhat irregularly triangular in outline, and presents for examination a base, an apex, an anterior wall, and a posterior or interventricular wall.

The Base.—The base of the right ventricle corresponds to the auriculo-ventricular septum. It is almost vertical, and extends from the opening of the pulmonary artery above to the auriculo-ventricular orifice below.

The greater part of the interior of the right ventricle is roughened by muscular prominences, termed *columnæ carneæ.* At the upper end of the base of the ventricle, where the pulmonary artery arises, the cavity is smooth, and devoid of such muscular prominences. This smooth portion is termed the *infundibulum,* or *the conus arteriosus.*

The Apex.—The apex of the right ventricle is situated upon the margo acutus, just to the right of the apex of the heart, which is formed entirely by the left ventricle. It corresponds to the junction, upon the margo acutus, of the anterior and posterior interventricular grooves.

The Anterior Wall.—This wall is thin and loose. It forms the greater part of the antero-superior surface of the heart, and is roughened throughout by the columnæ carneæ.

The Posterior or Interventricular Wall.—This wall corresponds to the interventricular septum. It projects somewhat into the cavity of the right ventricle. With the exception of the area termed the infundibulum, this wall is roughened throughout by the columnæ carneæ.

The Columnæ Carneæ.—The cavities of both ventricles are roughened by means of certain muscular bands, termed columnæ carneæ. Of these there are three varieties:—

Simple columnæ carneæ.
Trabeculæ carneæ.
Musculi papillares.

Simple Columnæ Carneæ.—These are muscular prominences which are attached to the ventricular walls throughout their whole extent. They project into the cavity of the ventricle, and are scattered indiscriminately over both walls of the ventricles.

Trabeculæ Carneæ.—These are attached to the ventricular wall at either end, but are free in the middle; they can consequently be raised up, whilst the simple columnæ carneæ cannot be so raised.

Musculi Papillares.—The musculi papillares are the largest but the least numerous of the columnæ carneæ. They form certain muscular bundles, termed the rudimentary, the anterior, and the posterior papillary muscles.

The *rudimentary papillary muscle* is ill defined. It consists of scattered muscular bands attached to the posterior or interventricular wall. The other extremity projects into the cavity of the ventricle, and is connected to the septal and infundibular cusps of the tricuspid valve by means of some small tendinous cords, the *chordæ tendineæ.*

The *anterior papillary muscle* is the largest and most constant of the musculi papillares. Its base is attached to the anterior wall of the ventricle close to the margo acutus. Its chordæ tendineæ connect it to the infundibular and marginal cusps of the tricuspid valve.

The *posterior papillary muscle* is often represented by two or three detached bundles. Its base is attached to the posterior or interventricular wall. Its chordæ tendineæ pass to the marginal and septal cusps of the tricuspid valve.

The Moderator Band.—The moderator band is a structure which stretches across the cavity of the right ventricle from the base of the anterior papillary muscle, upwards and inwards

to the interventricular septum. It is said to prevent over-distension of the ventricle.

Apertures of the Right Ventricle.—These are two in number, the auriculo-ventricular or tricuspid orifice and the orifice of the pulmonary artery.

The Auriculo-Ventricular or Tricuspid Orifice.—This is situated at the lowest part of the base of the ventricle, behind and to the right of the pulmonary orifice. It is somewhat circular in shape, with a circumference of about four inches.

Attached to the circumference of this orifice, and projecting into the interior of the right ventricle, there is a membranous valve. This valve is undivided at its circumferential attachment, but lower down it becomes separated into three distinct cusps or segments, hence its name of *tricuspid* valve.

The largest of these cusps projects downwards between the auriculo-ventricular orifice and the infundibulum; it is therefore termed the *infundibular* cusp.

A second cusp rests upon the posterior or interventricular wall, and is termed the *septal* cusp.

The third and least well-defined cusp is situated opposite the lateral margin of the ventricle, and is termed the *marginal* cusp.

In the notches between these three principal cusps there are occasionally smaller intermediate cusps, which, if present, render the recognition of the three principal cusps a matter of some difficulty.

Attached to the margins and ventricular surfaces of the three principal cusps are the chordæ tendineæ of the three papillary muscles. These are arranged as follows:—

To the adjacent margins and ventricular surfaces of the septal and infundibular cusps are attached the chordæ tendineæ of the rudimentary papillary muscle.

To the adjacent margins and ventricular surfaces of the infundibular and marginal cusps, the anterior papillary muscle.

To the adjacent margins and ventricular surfaces of the marginal and septal cusps, the posterior papillary muscle.

It is thus obvious that each cusp is under the control of two papillary muscles.

The tricuspid orifice is placed behind the right half of the sternum, opposite the fourth intercostal space and the inner end of the fifth right costal cartilage.

The Orifice of the Pulmonary Artery.—This is situated at the highest part of the base of the right ventricle, in front and to the left of the tricuspid orifice. It is circular in shape, and has a circumference of about three inches.

Attached to the circumference of this orifice, and projecting upwards into the interior of the artery itself, there is a valve consisting of three segments—right anterior, left anterior, and posterior, and named from the shape of its three segments the *semilunar valve.*

Each segment of this semilunar valve is attached by its convex margin to the circumference of the pulmonary artery. Its other extremity is free and concave, and projects into the cavity of the artery. In the centre of the free concave edge there is a thickened nodule, termed the *corpus Arantii.* On either side of this nodule the free edge is slightly concave, and is termed the *lunule.*

The pulmonary orifice is placed behind the upper edge of the third left costal cartilage, immediately to the left of the sternum.

The Cavity of the Left Auricle.—This is elongated transversely. It is rather smaller than the right auricle, and presents for examination a base, an apex, an anterior or inter-auricular wall, and a posterior wall.

The Base.—The base of the left auricle corresponds to its highest part. It extends from the openings of the left pulmonary veins, obliquely downwards and to the right, towards the openings of the right pulmonary veins.

Resting upon the base of the left auricle are the right and left branches of the pulmonary artery, whilst arching over these structures from before backwards is the arch of the aorta.

At either extremity of the base of the left auricle are the openings of the pulmonary veins. These are four in number, two on each side. Those of the right side open into the

auricle close to the inter-auricular septum, those of the left side close to the left auricular appendix. The pulmonary veins have no valves.

The Anterior or Inter-auricular Wall.—The anterior wall of the left auricle corresponds to the posterior wall of the right auricle. In this wall are seen the fossa ovalis and the opening into the left auricular appendix.

The *fossa ovalis* is situated between the openings of the pulmonary veins, and at a slightly higher level than in the right auricle, this being due to the obliquity of the foramen ovale of the fœtal heart. To the left of the fossa ovalis is the small aperture leading into the left auricular appendix.

The *left auricular appendix* is longer, narrower, and more curved than that of the right side. The tip of the left appendix is the only part of the left auricle which is seen on the antero-superior surface of the heart. The interior of the left auricular appendix is ridged by musculi pectinati, but these are entirely confined to the cavity of the appendix, so that on the left side the whole of the cavity of the auricle proper is smooth, and constitutes the atrium.

The Posterior Wall.—The posterior wall of the left auricle forms the posterior portion of the postero-inferior surface of the heart.

The Apex.—The apex corresponds to the left auriculo-ventricular or mitral orifice.

The Cavity of the Left Ventricle.—The cavity of the left ventricle is very similar to that of the right ventricle. It is ridged by columnæ carneæ, as is the right ventricle.

There are, however, only two papillary muscles; the cavity of the left ventricle is longer and narrower than that of the right; its walls are three times as thick; in transverse section the cavity of the left ventricle is oval, that of the right is crescentic; whilst, lastly, the apex of the left ventricle extends to and forms the true apex of the heart.

In the base of the left ventricle there are two openings—the auriculo-ventricular or mitral orifice and the aortic orifice.

The Auriculo-Ventricular or Mitral Orifice.—This is situated at the lower and back part of the base of the ventricle, behind and slightly to the left of the aortic orifice. It differs from the tricuspid orifice in its size and shape, the mitral orifice being oval in outline, with a circumference of about three and a half inches. The mitral orifice is guarded by a cuspidate valve, termed, from its supposed resemblance to a bishop's mitre, the *mitral* valve.

The mitral valve consists of two segments only, the larger of which projects into the cavity of the ventricle between the aortic and the mitral orifices; it is hence termed the aortic cusp, and is the only structure which separates those orifices. Both segments of this valve are controlled by the two papillary muscles in just the same way as are the cusps of the tricuspid valve.

The mitral orifice is placed behind the inner end of the fourth left costal cartilage and the adjacent part of the sternum.

The Aortic Orifice.—The aortic orifice is situated in front of and at a higher level than the mitral orifice. It is circular in outline, and is guarded by a semilunar valve, like the pulmonary orifice, the three cusps being right posterior, left posterior, and anterior. In other respects this valve resembles that of the pulmonary artery. Opposite these cusps, in both the aorta and the pulmonary artery, the wall is bulged out to form the *sinuses of Valsalva.* In the case of the aorta, the right coronary artery arises from the anterior sinus of Valsalva, and the left coronary artery from the left posterior sinus of Valsalva.

That part of the left ventricle which lies immediately below the orifice of the aorta is sometimes termed the *aortic vestibule.* Its walls contain no muscular fibres, but are composed of fibrous tissue only, and consequently they do not collapse during diastole of the ventricle, and hence a sufficient amount of space is provided for the proper action of the aortic valve.

The aortic orifice is placed behind the left half of the sternum, opposite the lower border of the third left costal cartilage. It is a little below and to the right of the pulmonary orifice, lying exactly behind the upper part of the infundibulum of the right ventricle.

Relative Positions of the Great Cardiac Orifices.—

The *right and left auriculo-ventricular orifices* lie side by side near the posterior part of the heart.

The *aortic orifice* lies between and in front of the two auriculo-ventricular orifices.

The *pulmonary orifice* lies immediately in front of the aortic orifice.

The orifices on the *right* side of the heart are therefore separated from one another by the aortic orifice, and lie at some little distance apart; those on the *left* side are, on the contrary, in apposition with one another.

Relations of the Heart to the Chest Wall.—The relations of the heart to the chest wall are, like those of the pleuræ and lungs, of the greatest practical importance, and must receive the most careful study.

(*a*) *The Area of the Deep Cardiac Dulness.*—The area which is described clinically as the area of the deep cardiac dulness, practically corresponds to the outline of the heart itself. It may be mapped out as follows:—

The *base*, that is, the region of the heart which gives origin to the great vessels, is indicated on the chest wall by a line drawn from a point situated on the lower border of the second left costal cartilage, one inch to the left of its junction with the sternum, to the upper border of the third right costal cartilage immediately to the right of its junction with the sternum.

The *right lateral limit* of the heart, that is, the base of the right auricle, is indicated by a line drawn from the last mentioned point to the seventh right chondro-sternal articulation, and arching outwards to a distance of one inch and a half from the middle line of the sternum.

The *margo acutus* of the right ventricle, that is, the lower border of the heart, is indicated by a line drawn slightly convex downwards, from the seventh right chondro-sternal articulation to the apex beat.

The *margo obtusus* of the left ventricle is indicated by a line drawn, slightly convex upwards, from the apex beat to a point situated on the lower border of the second left costal cartilage one inch to the left of its junction with the sternum.

(*b*) *The Area of the Superficial Cardiac Dulness.*—The area which is described clinically as the area of the superficial cardiac dulness denotes that part of the heart which is uncovered by the lungs.

It may be mapped out by taking three points and joining these together by means of three lines. The three points to be taken are—a point just internal to the apex beat; a second point, in the middle line of the sternum opposite the fourth costal cartilage; and a third point, in the middle line of the sternum opposite the xiphi-sternal articulation.

(*c*) *The Auriculo-Ventricular Groove.*—This is indicated by a line drawn from the third left chondro-sternal articulation, downwards and slightly to the right, to the sixth right chondro-sternal articulation. The practical importance of being able to map out this groove on the living subject consists in the fact that the cardiac valves lie either in or very near this groove.

(*d*) *The Tricuspid Orifice.*—The tricuspid orifice is placed behind the right half of the sternum, opposite the fourth intercostal space and the inner end of the fifth right costal cartilage.

(*e*) *The Mitral Orifice.*—The mitral orifice is placed behind the inner end of the fourth left costal cartilage and the adjacent part of the sternum.

(*f*) *The Pulmonary Orifice.*—The pulmonary orifice is placed behind the upper edge of the third left costal cartilage, immediately to the left of the sternum.

(*g*) *The Aortic Orifice.*—The aortic orifice is placed behind the left half of the sternum, opposite the lower border of the third left costal cartilage.

(*h*) *The Apex of the Heart.*—The cardiac apex is situated in the fifth left intercostal space one and a half inches below the nipple, and three and a half inches to the left of the middle line of the body.

(*i*) *The Apex of the Right Auricular Appendix.*—The apex of the right auricular appendix is placed behind the middle line of the sternum opposite the third costal cartilage.

(*j*) *The Apex of the Left Auricular Appendix.*—The apex of the left auricular appendix is placed behind the third left

costal cartilage, one inch and a quarter to the left of the sternum.

The Cardiac Plexus.—The cardiac plexus, which consists of two parts, superficial and deep, is specially intended for the supply of the heart, and to a lesser extent of the lungs. It forms one of the three prevertebral plexuses of the sympathetic system.

The Superficial Cardiac Plexus.—The superficial cardiac plexus lies in the concavity of the arch of the aorta, between the right pulmonary artery and the ligamentum arteriosum.

It is formed by the two cardiac nerves which descend on the left side of the arch of the aorta, that is, by the inferior cervical cardiac branch of the left vagus nerve and by the superior cervical cardiac branch of the left gangliated cord of the sympathetic. The junction of these two nerves in the plexus is often indicated by the presence of a small ganglion, —the *ganglion of Wrisberg.*

Branches.—The superficial cardiac plexus supplies filaments to the anterior pulmonary plexus of the left side, and terminates in the *right coronary plexus,* which is distributed to the right side of the heart.

The Deep Cardiac Plexus.—The deep cardiac plexus lies on the right side of the arch of the aorta, immediately in front of the bifurcation of the trachea.

It is formed by the following nerves:—

The superior, middle, and inferior cervical cardiac branches of the right vagus.
The thoracic cardiac branches of the right vagus.
The superior and middle cervical cardiac branches of the left vagus.
The thoracic cardiac branches of the left vagus.
The superior, middle, and inferior cervical cardiac branches of the right gangliated cord of the sympathetic.
The middle and inferior cervical cardiac branches of the left gangliated cord of the sympathetic.

There are thus fourteen cardiac nerves in all, of which two pass to the superficial cardiac plexus and twelve to the deep cardiac plexus.

Branches.—From the *right* side of the deep cardiac plexus branches are given off as follows:—

To the right coronary plexus.
To the left coronary plexus.
To the right auricle.
To the right anterior pulmonary plexus.

From the *left* side of the deep cardiac plexus branches are given off as follows:—

To the left coronary plexus for the supply of the left side of the heart.
To the superficial cardiac plexus.
To the left auricle.
To the left anterior pulmonary plexus.

The Pulmonary Artery.—The pulmonary artery arises from the infundibulum of the right ventricle, behind the upper edge of the third left costal cartilage immediately to the left of the sternum. It passes upwards and backwards for two inches, to terminate below the concavity of the arch of the aorta, opposite the disc between the fifth and sixth dorsal vertebræ, by dividing into right and left pulmonary arteries.

In this course the pulmonary artery curves round the ascending aorta, at first lying in front of that vessel and then on its left side, whilst at its termination the pulmonary artery lies altogether behind the plane of the ascending aorta.

On either side of the pulmonary artery, at its commencement, are the corresponding coronary arteries and the auricular appendices, whilst behind and below the vessel is the left auricle.

The vessel is almost entirely enclosed within the fibrous pericardium, the serous layer of which forms a single tubular sheath common to this vessel and the ascending aorta.

The Right Pulmonary Artery.—This vessel passes transversely outwards and to the right, behind the ascending aorta and the superior vena cava, to the root of the right lung. Above it is the arch of the aorta, and below it the left auricle.

The Left Pulmonary Artery.—This vessel passes hori-

zontally backwards and outwards, in front of the left bronchus and the descending thoracic aorta, to the root of the left lung.

From the upper part of this vessel, just to the left of the bifurcation of the pulmonary artery into its right and left branches, is a short fibrous cord—the *ligamentum arteriosum*—which runs upwards and backwards to the arch of the aorta.

The ligamentum arteriosum is the remains of the *ductus arteriosus*, the continuation of the pulmonary trunk in the fœtal heart. Just behind the ligamentum arteriosum the left recurrent laryngeal nerve hooks round the arch of the aorta, to ascend on its right side.

The Pulmonary Veins.—These are four in number, two on each side. Those of the *right* side pass behind the superior vena cava and the right auricle, to terminate in the left auricle. Those of the *left* side pass in front of the descending thoracic aorta.

The Thoracic Aorta.—The aorta in the thorax is divided into three parts :—

The ascending aorta.
The arch of the aorta.
The descending thoracic aorta.

The Ascending Aorta.—This vessel commences at the upper and anterior part of the base of the left ventricle of the heart, immediately behind the upper end of the infundibulum of the right ventricle. Its commencement lies behind the left half of the sternum, on a level with the lower border of the third left costal cartilage.

From this origin the ascending aorta passes upwards, forwards, and to the right, to terminate opposite the second right costal cartilage, or the *aortic cartilage*, by becoming directly continuous with the arch of the aorta.

The ascending aorta is about two inches long, and lies in the middle mediastinum.

Near the origin of the vessel, and in its interior, there are three nearly equal dilatations, termed the *sinuses of Valsalva*; these are situated one in front and the other two behind, to the right and left respectively. From the anterior sinus of

Valsalva arises the right coronary artery, whilst the left coronary artery arises from the left posterior sinus.

On the right side of the ascending aorta there is a fourth dilatation, termed the *great sinus of the aorta*; it is usually better marked in old persons, and is a common site for aneurism.

The ascending aorta is entirely covered by the fibrous pericardium, and is enclosed, with the pulmonary artery, in a common sheath of visceral pericardium.

Relations.—*In front* of the vessel from below upwards there are the origin of the pulmonary artery, the right auricular appendix, and lastly the sternum. The ascending aorta is separated from the sternum by the pericardium, the right pleura, the fat of the anterior mediastinum, and to a variable extent by the thin anterior margin of the right lung.

Behind, there are the right pulmonary artery and the left auricle.

On the *right* side, from above downwards, the superior vena cava and the right auricle.

On the *left* side, the trunk of the pulmonary artery.

Branches.—The right and left coronary arteries.

The Arch of the Aorta.—The arch of the aorta commences opposite the second right costal cartilage or the aortic cartilage, as the direct continuation of the ascending aorta. It passes backwards and slightly to the left, and then directly backwards, to terminate opposite the lower border of the fourth dorsal vertebra, by becoming directly continuous with the descending thoracic aorta. In this way the vessel describes a slight curve round the trachea, its highest point crossing the mesial plane of the body one inch below the interclavicular notch of the manubrium sterni. It lies in the superior mediastinum, and it is important to note that this vessel runs in an antero-posterior direction, and not in the transverse direction.

Relations.—On the right side, from before backwards, there are:—

The deep cardiac plexus.
The trachea.

The left recurrent laryngeal nerve.
The œsophagus.
The thoracic duct.

On the left side from before backwards—

The left phrenic nerve.
The inferior cervical cardiac branch of the left pneumogastric nerve.
The superior cervical cardiac branch of the left sympathetic nerve.
The left pneumogastric nerve.
The left superior intercostal vein.

Below the arch of the aorta—

The bifurcation of the pulmonary artery.
The superficial cardiac plexus.
The ligamentum arteriosum.
The left recurrent laryngeal nerve.
The left bronchus.

Above the arch of the aorta—

The left innominate vein.
The branches of the arch of the aorta.

The relations of the arch of the aorta are of considerable practical importance in connection with the question of aneurism of the vessel, and the student will do well to ask himself what will be the effects of pressure on the various structures which have just been enumerated as forming the relations of this vessel, or, in other words, what are the symptoms of aneurism of the arch of the aorta ?

Branches.—The arch of the aorta gives off, from before backwards, three large vessels :—

The innominate artery.
The left common carotid artery.
The left subclavian artery.

The Innominate Artery.—This vessel arises from the upper surface of the arch of the aorta, and, passing obliquely upwards and to the right for a distance of one or two inches, terminates behind the right sterno-clavicular articulation, opposite the upper border of the clavicle, by dividing into the right subclavian and right common carotid arteries.

Relations.—*In front* of the vessel from above downwards are the right sterno-clavicular articulation, the manubrium sterni, from which it is separated by the origins of the sterno-hyoid and sterno-thyroid muscles, and the remains of the thymus gland; and, lastly, the left innominate vein crosses the artery obliquely near its origin.

Behind are the pleura, and lower down the trachea.

To the *right* side, the right innominate vein and the superior vena cava.

To the *left* side, near the termination of the artery, there is the trachea.

Branches.—The innominate artery usually gives off no branches. It may occasionally, however, give off the *thyroidea ima*, a small vessel which, when present, passes up to the thyroid gland in front of the trachea. Its possible presence must be remembered in connection with the operation of low tracheotomy.

The Left Common Carotid Artery.—This vessel, like the left subclavian artery, arises in the thorax and terminates in the neck. In each case only the intra-thoracic portion is now described.

The left common carotid artery arises from the arch of the aorta, near its middle, and very near the origin of the innominate artery. It passes obliquely upwards and to the left, to terminate in the neck.

Relations.—*In front* there are the remains of the thymus gland and the left innominate vein.

Behind, from below upwards, the trachea, the œsophagus, and the thoracic duct.

To its outer or *left* side, the pleura, lung, and pneumogastric nerve of the left side.

The Left Subclavian Artery.—This vessel arises from the arch of the aorta near its posterior extremity, and passes almost vertically upwards into the neck.

Relations.—*In front* of the vessel, in its intra-thoracic part, there are the left common carotid artery and the left innominate vein, together with the left pneumogastric nerve.

Behind, from below upwards, are the œsophagus, the thoracic duct, and the longus colli muscle.

To the inner or *right* side of the artery are the trachea,

the œsophagus, the thoracic duct, and the left recurrent laryngeal nerve.

On its outer or *left* side, the artery is in contact with the left mediastinal parietal pleura and the left lung.

The arch of the aorta and its three branches all lie in the superior mediastinum.

The Trachea.—The trachea lies in the middle line of the neck and superior mediastinum of the thorax.

It commences in the neck opposite the lower border of the cricoid cartilage, or opposite the sixth cervical vertebra, and, passing downwards into the superior mediastinum of the thorax, ends opposite the intervertebral disc between the fourth and fifth dorsal vertebræ, by dividing into the right and left bronchi. Its length is variable, but averages about four and a half inches.

The trachea is a wide tube which is kept constantly patent by a series of some sixteen to twenty cartilaginous rings which are embedded in its walls. These rings, which are somewhat C-shaped, are deficient posteriorly, and the trachea is, in consequence, slightly flattened behind.

Intra-Thoracic Relations.—The trachea lies in the superior mediastinum, and has the following relations:—

In Front.—The left innominate vein is in immediate contact with the upper part of the trachea, in front of which, from before backwards, are the manubrium sterni, the origins of the sterno-hyoid and sterno-thyroid muscles, and the remains of the thymus gland.

In its lower part the trachea is in direct contact with the innominate and left common carotid arteries, these vessels diverging to the right and left respectively as they pass upwards out of the thorax.

Behind.—Immediately behind the trachea is the œsophagus, which separates it from the vertebral column.

To the Right.—The mediastinal pleura which separates the trachea from the right lung, and the right vagus nerve. At a higher level the innominate artery comes to lie to the right of the trachea.

To the Left.—The arch of the aorta which crosses the trachea from before backwards, the left common carotid and left subclavian arteries, the left recurrent laryngeal nerve, and some cardiac branches. Still further to the left is the left mediastinal pleura, which separates the trachea from the left lung.

At the level of the bifurcation of the trachea there are, in front, the deep cardiac plexus, the pericardium, and the auricles of the heart.

In front and slightly below the bifurcation of the trachea is the right pulmonary artery.

The Bronchi.—The bronchi are two in number, and result from the bifurcation of the trachea. They pass to their respective lungs.

Relations of the Right Bronchus.—The superior vena cava passes downwards in front of the right bronchus, whilst the vena azygos major arches forwards above it, to end in the superior vena cava.

Relations of the Left Bronchus.—The left bronchus passes downwards and outwards below the arch of the aorta, and in front of the œsophagus and the descending thoracic aorta.

Differences between the two Bronchi. — The right bronchus is shorter and wider than the left, the right being about one inch in length, the left two inches; whilst the cross sectional area of the right bronchus, as compared with that of the left, is as 100 is to 78.

The right bronchus is more nearly vertical than the left; hence foreign bodies are more usually found lodged in the right bronchus.

The right bronchus gives off an eparterial bronchus, the left does not; and, lastly, the relations of the two bronchi differ on the two sides.

The Posterior Mediastinum. — The posterior mediastinum has already been defined as lying behind the pericardium.

Its precise boundaries are as follows:—

In front, the pericardium and the diaphragm.

Behind, the bodies of the eight lower dorsal vertebræ, the intervertebral discs, and the anterior common ligament of the vertebræ.

Above, by the imaginary line drawn from the lower border of the manubrium sterni to the lower border of the body of the fourth dorsal vertebra.

Laterally, by the mediastinal pleuræ.

The Pneumogastric Nerves.—The pneumogastric or the vagi nerves form the tenth pair of cranial nerves, and run successively through the neck, the thorax, and on into the abdomen. The intra-thoracic course of the two nerves differs somewhat.

The Right Pneumogastric Nerve.—This nerve enters the thorax in front of the first part of the subclavian artery and behind the right innominate vein, and passes downwards through the superior mediastinum on the side of the trachea.

Entering the posterior mediastinum, the nerve spreads out on the back of the root of the lung to form the *posterior pulmonary plexus*, from whence it emerges in the form of two cords which pass on to the œsophagus, and unite with similar filaments from the left pneumogastric nerve to form the *plexus gulæ* or the œsophageal plexus.

At the lower part of the thorax the nerve again forms a single trunk, which leaves the thorax on the back of the œsophagus through the œsophageal aperture of the diaphragm, and entering the abdomen is finally distributed to the posterior surface of the stomach and to the solar plexus.

The Left Pneumogastric Nerve.—This nerve enters the thorax behind the left innominate vein, between the left common carotid and left subclavian arteries. It then passes downwards on the left side of the arch of the aorta, round which its recurrent laryngeal branch turns upwards and inwards.

The nerve then enters the posterior mediastinum, and spreads out on the back of the root of the left lung to form the posterior pulmonary plexus. The nerve then descends to take part in the formation of the *plexus gulæ*, from whence it reappears as a single cord which runs in front of the œsophagus, and on into the abdomen to the anterior surface of the stomach.

Intra-Thoracic Branches of the Pneumogastric Nerves.—These are as follows:—

Thoracic cardiac branches.
Pulmonary branches.
Œsophageal branches.
Pericardial branches.
The left recurrent laryngeal nerve.

Thoracic Cardiac Branches.—On the *right* side these arise whilst the nerve is in contact with the trachea. They pass inwards to the deep cardiac plexus.

On the *left* side they arise entirely from the left recurrent laryngeal nerve, and also pass to the deep cardiac plexus.

Pulmonary Branches.—On *each* side pulmonary branches are derived from the pneumogastric nerves; these are the anterior pulmonary branches.

The *anterior pulmonary nerves* are usually two or three in number, which pass down to the front of the root of the lung, and, uniting with filaments from the sympathetic nerves on the pulmonary artery, and with branches from the deep cardiac plexus, form the anterior pulmonary plexus.

Œsophageal Branches.—These are derived from the pneumogastric nerves, both above and below the level of the pulmonary plexuses; the latter are the larger of the two sets, and form the *plexus gulæ.*

Pericardial Branches.—These are small branches given off to the pericardium.

The Left Recurrent Laryngeal Nerve.—This important nerve arises from the left pneumogastric nerve opposite the arch of the aorta. It passes inwards below the aortic arch and immediately behind the ligamentum arteriosum, and then ascends on the right side of the arch of the aorta and in the interval between the trachea and the œsophagus to the larynx. It supplies all the muscles of the left side of the larynx except the left crico-thyroid. The *right recurrent laryngeal nerve* arises in the neck, and hooks round the first part of the subclavian artery.

The relations of the left recurrent laryngeal nerve to the arch of the aorta are of the highest practical importance in connection with aneurism of that vessel.

The Œsophagus.—The œsophagus commences in the neck, opposite the lower border of the cricoid cartilage, or the sixth cervical vertebra. It passes successively through the neck, the superior mediastinum, the posterior mediastinum, and terminates in the abdomen opposite the tenth or eleventh dorsal vertebra by opening into the stomach.

The œsophagus is about nine or ten inches long, and presents three slight curvatures.

The first of these curvatures is in the antero-posterior direction, and corresponds to the curvature of the vertebral column.

The other two curvatures are in the lateral direction, and are as follows:—Commencing in the middle line, the œsophagus deviates to the left side as it passes to the root of the neck; hence œsophagotomy is always performed upon the left side. From the root of the neck, the œsophagus passes back again to the middle line, which it regains about the level of the fifth dorsal vertebra, and from this point onwards the œsophagus again deviates to the left side, at the same time passing forwards to leave the thorax at the œsophageal aperture of the diaphragm.

Intra-Thoracic Relations.—*In front* of the œsophagus from above downwards there are:—

The lower part of the trachea.

The commencement of the left bronchus, which crosses the œsophagus, and is sometimes connected with it by an unimportant muscle, the *broncho-œsophageal* muscle.

The pericardium.

The diaphragm.

Behind the œsophagus, in the *upper dorsal region*, there is the vertebral column, with the origins of the longus colli muscles.

In the *mid-dorsal region* the œsophagus is separated from the vertebral column by:—

The thoracic duct, which passes obliquely upwards from right to left behind the œsophagus, and then ascends on its left side.

The vena azygos major, which lies behind and slightly to the right side of the œsophagus.

The vena azygos minor superior, the vena azygos minor inferior, and the right aortic intercostals pass behind the œsophagus, the first two to terminate in the vena azygos major, and the last to supply the intercostal spaces.

In the *lower dorsal region* the œsophagus is separated from the vertebral column by the descending thoracic aorta.

Upon its *right* side the œsophagus is, in the posterior mediastinum, clothed by the mediastinal parietal pleura, which often extends inwards behind it, forming the retro-œsophageal cul-de-sac.

Upon the *left* side of the œsophagus there are, in the *superior* mediastinum:—

The thoracic duct.
The left mediastinal parietal pleura.
The arch of the aorta.

In the *posterior* mediastinum there are on the *left* side of the œsophagus, from above downwards:—

The descending thoracic aorta.
The left mediastinal parietal pleura.

On each side of the upper part of the œsophagus there are the pneumogastric nerves, which form a plexus around it—the plexus gulæ. These two nerves gradually change their position in such a way that the left pneumogastric nerve comes to lie in front of the œsophagus, and the right behind.

Relations of the Œsophagus to the Thoracic Aorta.—The relations of the œsophagus to the thoracic aorta are of exceptional practical importance, and must be carefully studied.

The œsophagus, in the *superior mediastinum*, lies on the right side of, and in direct contact with the arch of the aorta.

As the œsophagus descends through the *posterior mediastinum* it inclines slightly to the left. It therefore lies first on the right side, and then directly in front of the descending thoracic aorta.

At the *œsophageal aperture in the diaphragm* the œsophagus

lies in front and to the left side of the descending thoracic aorta.

Arterial Supply of the Œsophagus.—In the *neck* the œsophagus is supplied by the inferior thyroid artery; in the *thorax*, by branches from the descending thoracic aorta direct, from the bronchial arteries, and from the aortic intercostal arteries; in the *abdomen*, by branches from the coronary artery.

The Thoracic Duct.—The thoracic duct commences in the abdomen opposite the second lumbar vertebra, in a dilatation termed the *receptaculum chyli.* It passes upwards through the posterior and superior mediastina of the thorax, and terminates in the neck by opening into the outer angle of junction of the left internal jugular vein with the left subclavian vein. Its length is from fifteen to eighteen inches.

The thoracic duct enters the thorax through the aortic orifice of the diaphragm, lying between the vena azygos major on the right, and the descending thoracic aorta on the left. Running upwards through the posterior mediastinum, the duct gradually inclines to the left behind the œsophagus. Entering the superior mediastinum, it passes to the right of the arch of the aorta, and then ascends on the left side of the œsophagus, between it and the left subclavian artery.

The thoracic duct possesses valves, which are better marked at its upper part. It receives the lymphatic vessels from the lower limbs, from the abdomen with the exception of the upper surface of the liver, from the left side of the thorax, from the left upper limb, and from the left side of the head and neck.

The Descending Thoracic Aorta.—The descending thoracic aorta commences at the lower border of the fourth dorsal vertebra as the direct continuation of the arch of the aorta. It descends in the posterior mediastinum, to terminate opposite the lower border of the twelfth dorsal vertebra by becoming directly continuous with the abdominal aorta. It is about seven or eight inches long.

At its commencement the descending thoracic aorta lies slightly to the left of the middle line of the body, but as it descends it inclines slightly inwards, so that at its termination it is either mesial or nearly so in position.

Relations.—*In front* of the descending thoracic aorta are the root of the left lung, the pericardium, the diaphragm, and near the termination of the vessel the œsophagus comes to lie in front of it.

Behind the descending thoracic aorta are the bodies of the lower eight dorsal vertebræ and the corresponding intervertebral discs, together with the azygos veins of the left side.

To the *right side* are the vena azygos major, the thoracic duct, and the œsophagus (except at the lower part, where, as has been already pointed out, that structure comes to lie in front of the artery).

To the *left side*, the left pleura and lung.

Branches.—The branches of the descending thoracic aorta may be classified as follows:—

Visceral.
  The pericardial arteries.
  The bronchial arteries.
  The œsophageal arteries.
  The posterior mediastinal arteries.
Parietal.
  The nine pairs of intercostal arteries.

The Pericardial Arteries.—These are unimportant vessels which supply the pericardium.

The Bronchial Arteries.—These vessels are the nutrient arteries for the substance of the lung. They vary both in their number and in their mode of origin. Most usually there is, on the *right* side, a single vessel which either arises from the first intercostal artery, or by a common trunk, in common with the upper of the two left bronchial arteries, from the descending thoracic aorta itself.

On the *left* side there are most usually two bronchial arteries, upper and lower, which arise from the descending thoracic aorta.

The bronchial arteries enter their respective lungs on the posterior part of the root of the lung, and ramify in the substance of the lung.

The Œsophageal Arteries.—These vessels, like the bronchial arteries, vary in their number and origin. They are

most usually four or five in number, and, arising from the front of the descending thoracic aorta, run downwards upon the œsophagus.

Above, they anastomose with the œsophageal branches of the inferior thyroid artery, and below, with the œsophageal branches of the coronary artery from the cœliac axis, a branch of the abdominal aorta.

The Posterior Mediastinal Branches.—These are small vessels supplying the glands and other structures in the posterior mediastinum.

The Intercostal Arteries.—These have already been described with the thoracic wall. (*See* page 203.)

The Azygos Veins.—The azygos veins are three in number:—

The vena azygos major.
The vena azygos minor inferior.
The vena azygos minor superior.

They form the channels by means of which the venous blood from the intercostal spaces is returned into the right auricle.

The Vena Azygos Major.—This vein is situated on the right side. It commences in the abdomen, most usually as the upward continuation of the *ascending lumbar vein*—a vein which connects together the lumbar veins. It may, however, commence less frequently in the inferior vena cava or even in the right renal vein.

Passing upwards, the vena azygos major enters the thorax through the aortic orifice of the diaphragm, lying there immediately to the right of the thoracic duct and the abdominal aorta.

The vein then runs upwards through the posterior mediastinum of the thorax, in front of the bodies of the dorsal vertebræ, until it reaches the level of the fifth rib, where it turns forwards above the root of the right lung, to terminate, in the middle mediastinum, in the superior vena cava.

The vena azygos major drains, either directly or indirectly, all the twenty-two intercostal spaces, except the first intercostal space of the right side, and the first three or four intercostal spaces of the left side.

Tributaries.—The tributaries of the vena azygos major are as follows:—

- The right superior intercostal vein.
- The intercostal veins of the right side, from the fifth to the eleventh intercostal spaces inclusive.
- The vena azygos minor superior.
- The vena azygos minor inferior.
- The right bronchial vein.
- Œsophageal, pericardial, and posterior mediastinal veins.

The Vena Azygos Minor Inferior.—This vein commences in the abdomen in almost the same way as the vena azygos major. It enters the thorax through the left crus of the diaphragm. It runs upwards as high as the ninth dorsal vertebra, at which point it crosses behind the descending thoracic aorta, the œsophagus, and the thoracic duct, to terminate in the vena azygos major.

Tributaries.—The tributaries of the vena azygos minor inferior are as follows:—

- The intercostal veins from the three or four lower intercostal spaces of the left side.
- Mediastinal veins.

The Vena Azygos Minor Superior.—This vein, unlike the other two, is entirely confined to the thorax. It is formed by the union of the intercostal veins of the fourth to the seventh spaces of the left side. It turns inwards behind the descending thoracic aorta, the œsophagus, and the thoracic duct, to terminate in the vena azygos major opposite the eighth dorsal vertebra. Occasionally the vein terminates in the vena azygos minor inferior instead of in the major.

Tributaries.—The tributaries of the vena azygos minor superior are as follows:—

- The intercostal veins of the left side, from the fourth to the seventh intercostal spaces inclusive.
- Mediastinal veins.
- The left bronchial vein.

Method of Termination of the Intercostal Veins in the Azygos Veins.—*On the Right Side.*—The first intercostal vein is frequently termed the *highest intercostal vein.* It

terminates in the right innominate vein, or more frequently in the vertebral vein.

The intercostal veins from the second, third, and fourth intercostal spaces unite to form a single venous trunk, the *superior intercostal vein*, which terminates in the vena azygos major.

The remaining intercostal veins of the right side terminate as single trunks in the vena azygos major.

On the Left Side.—The *highest intercostal vein* terminates in the left innominate vein, or more frequently in the left vertebral vein.

The intercostal veins from the second and third spaces unite to form a single venous trunk, the *superior intercostal vein*, which terminates in the left innominate vein.

The intercostal veins from the fourth to the seventh spaces unite to form the vena azygos minor superior, which eventually terminates in the vena azygos major.

The intercostal veins from the remaining spaces on the left side terminate in the vena azygos minor inferior, which opens into the vena azygos major.

The Gangliated Cords of the Sympathetic within the Thorax.—The gangliated cords of the sympathetic within the thorax run downwards in front of the heads of the ribs behind the costal parietal pleura, and are not, therefore, within any of the various mediastinal spaces.

The gangliated cord of the sympathetic enters the thorax immediately in front of the neck of the first rib, having the superior intercostal artery and the greater portion of the anterior primary division of the first dorsal nerve to its outer side.

From thence the cord inclines slightly inwards, descending in front of the heads of the ribs, until, at the lower part of the thorax, it inclines still nearer the middle line, and so comes to lie in front of the bodies of the dorsal vertebræ. It leaves the thorax, and enters the abdomen by passing behind the internal arcuate ligament of the diaphragm.

In this course the gangliated cords lie entirely behind the costal parietal pleura, and in front of the heads of the ribs and the intercostal vessels. On each cord there are usually eleven or twelve ganglia, the largest of which are at the upper part of the cord.

Branches.—The branches of the gangliated cords of the sympathetic within the thorax are divided into internal and external.

The External Branches.—From each ganglion two branches are given off which connect the cord to the various spinal nerves.

The Internal Branches.—From the first six ganglia branches are given off to the aorta, the vertebræ, and the ligaments, whilst the third and fourth ganglia give off, in addition, branches to the posterior pulmonary plexus.

The *great splanchnic nerve* arises from the sixth to the tenth ganglia inclusive. It descends obliquely inwards in front of the bodies of the lower dorsal vertebræ, and, piercing the crus of the diaphragm, terminates in the abdomen in the semilunar ganglion of the solar or epigastric plexus.

The *small splanchnic nerve* arises from the tenth and eleventh ganglia. It accompanies the great splanchnic nerve into the abdomen.

The *least splanchnic nerve* arises from the last ganglion, and, piercing the crus of the diaphragm, enters the abdomen, and terminates in the renal plexus.

The Right Lymphatic Duct.—This is a short vessel, about half an inch in length, which drains the right upper limb, the right side of the head and neck, the right half of the thorax, and the upper surface of the liver. It terminates in the outer angle of junction of the right subclavian and right internal jugular veins.

The Lymphatic Glands of the Thorax.—Lymphatic glands are found in the thorax as follows:—

A Chain of Sternal Glands accompanying the Internal Mammary Artery.—These glands drain the anterior walls of the thorax and abdomen, the diaphragm in part, and the inner part of the mamma.

A Chain of Intercostal Glands lying in front of the Heads of the Ribs.—These drain the posterior wall of the thorax and the costal pleura.

The Anterior Mediastinal Glands.—These glands, three or

four in number, drain the upper surface of the liver and the diaphragm.

The Posterior Mediastinal Glands.—This chain of glands is found along the sides of the descending thoracic aorta and œsophagus. They drain the œsophagus, the pericardium, and the diaphragm.

The Superior Mediastinal or Cardiac Glands.—These are found chiefly in connection with the innominate veins and the arch of the aorta. They drain the heart, the pericardium, and the thymus gland.

The Bronchial Glands.—These lie about the bifurcation of the trachea, and through them the lymphatics of the lungs pass. The bronchial glands are connected above with the cardiac glands, and thence with the thoracic and right lymphatic ducts.

The Fœtal Circulation.—To realise the significance of the various embryonic remnants which are found in the abdomen and thorax in connection with the circulatory system, it is imperative to be familiar with the course of the blood in the fœtus and the changes which occur at the time of birth.

In studying the fœtal circulation, two facts must be thoroughly understood and always kept prominently in mind:—

1. All the fœtal blood is purified in the placenta.
2. The fœtal lungs are functionless.

Course of the Blood in the Fœtus.—The venous blood of the fœtus is purified in the placenta, from whence it passes as arterial blood through the single umbilical vein in the cord to the umbilicus of the fœtus. From the umbilical cord the umbilical vein ascends in the falciform ligament of the liver to the transverse fissure of the liver, where it joins the left division of the portal vein; the purified blood carried by the umbilical vein passes partly into the liver by the right and left divisions of the portal vein, but by far the greater proportion of it ascends from the left division of the portal vein by means of the ductus venosus into one of the hepatic veins, through which it joins the upper end of the inferior vena cava; the placental blood mixes with the venous blood in the inferior vena cava, and by means of this vein the now mixed blood is thrown into the right auricle.

From the right auricle the mixed blood is guided by the Eustachian valve which guards the termination of the fœtal inferior vena cava, through the foramen ovale, straight into the left auricle, where it is joined by the small amount of blood which circulates through the fœtal lungs, and which is returned into the left auricle by means of the pulmonary veins.

From the left auricle the mixed blood passes through the left ventricle into the ascending aorta and the arch of the aorta, and by means of the branches of the latter vessel is conveyed to the brain, head and neck, and the two upper limbs, where it loses its oxygen and becomes venous blood.

The venous blood from the brain, head and neck, and the two upper limbs is eventually returned into the right auricle by the superior vena cava; this blood then passes through the right auricle into the right ventricle. It therefore follows that there is a double current through the fœtal right auricle.

1. There is the mixed blood passing from the inferior vena cava, through the auricle and the foramen ovale into the left auricle.

2. There is the venous blood from the brain, head and neck, and the two upper limbs, passing by way of the superior vena cava through the right auricle into the right ventricle.

It is probable that there is very little admixture, if indeed any at all, between the two currents of blood which thus pass through the right auricle.

The venous blood having reached the right ventricle is now conveyed into the pulmonary artery, in which a separation of the blood is effected.

(*a*) *A very small part of the venous blood* passes through the right and left divisions of the pulmonary artery into the functionless lungs, from whence it is returned into the left auricle by means of the pulmonary veins. In the left auricle

it mingles with the mixed blood which is to pass to the brain, head and neck, and the two upper limbs.

(*b*) *The greater portion of the venous blood* is thrown from the left pulmonary artery, through the ductus arteriosus, into the arch of the aorta beyond the origin of the left subclavian. In the aorta this venous blood mingles with that purer portion of the mixed blood which has not passed to the brain, head and neck, and the two upper limbs, but which has proceeded from the arch of the aorta into the descending thoracic aorta. Consequently this vessel contains, in the fœtus, mixed blood like that in the arch, but of a much impurer nature, inasmuch as it now consists of the venous blood from the brain, head and neck, and the two upper limbs, mingled with the purer blood from the left ventricle. The object of the ductus arteriosus joining the arch of the aorta beyond the origin of the left subclavian is, of course, to ensure the purest blood—mixed though it be—passing to the brain.

The mixed and impurer blood which descends through the descending thoracic aorta supplies the abdominal viscera in the usual way, and eventually passes on into the common iliac arteries, which may be described, in the fœtus, as dividing into external iliac and umbilical arteries.

(*a*) *The external iliac arteries* convey the mixed and impurer blood to the lower limbs, where it loses the little oxygen it possesses and becomes venous blood. This venous blood is returned by the inferior vena cava into the right auricle.

(*b*) *The umbilical arteries* convey the greater proportion of the mixed and impurer blood through the umbilicus and cord to the placenta, where it is purified.

Peculiarities of the Fœtal Circulation.—The most striking peculiarity of the fœtal circulation is, that with the single exception of the *umbilical vein* there is no vessel which contains purely arterial blood. All the other vessels, without any exception, contain blood which is more or less impure.

The purest blood is that which passes through *the aortic arch and its branches* to the brain and upper part of the body.

The descending thoracic aorta and all its branches contain highly impure blood.

The umbilical arteries do not convey venous blood to the placenta, as might be expected, but the highly impure blood just referred to.

The superior vena cava contains venous blood only.

The inferior vena cava is very peculiar. Near its termination it contains :—

1. Arterial blood conveyed to it by the umbilical vein, ductus venosus, and one of the hepatic veins.
2. Mixed blood which has circulated through the liver from the hepatic artery, portal vein, and umbilical vein, and which is returned to the inferior vena by means of the hepatic veins.
3. Venous blood from the lower half of the body.

The Changes which occur at Birth.—At birth respiration is at once established, and the lungs become functionally active, consequently there is a very rapid dilatation of the various pulmonary vessels.

With the ligation of the umbilical cord the placental circulation is suddenly arrested.

The result of these two sudden and almost simultaneous changes is very marked.

The Umbilical Vein.—As a result of the ligation of the umbilical cord, the blood current through the umbilical vein is absolutely and instantaneously arrested. The vein commences to atrophy, as does also the ductus venosus, and by the sixth or seventh day of extra-uterine life their obliteration is usually completed.

In the adult the umbilical vein remains as a fibrous cord —the *round ligament of the liver*—which extends, between the two layers of the peritoneal falciform ligament, from the umbilicus along the anterior half of the longitudinal fissure of the liver to the transverse fissure, where it joins the left division of the portal vein.

The *ductus venosus* remains in the adult as a fibrous cord, which lies in the posterior half of the longitudinal fissure, and extends from the left division of the portal vein to the upper end of the inferior vena cava.

As a necessary result of the elimination of the cross current of blood through the left division of the portal vein, consequent on ligation of the umbilical vein, the portal system rapidly enlarges.

The Foramen Ovale.—At the moment of birth the lungs become suddenly functionally active, and blood ceases to flow through the foramen ovale, because it is imperative for all the venous blood to pass into the right ventricle and pulmonary artery in order to reach the new centres of oxygenation—the lungs.

Notwithstanding the sudden cessation of the blood current through the foramen ovale, its obliteration proceeds but slowly, and in many instances, even in the adult, is not absolutely finished, as it is of frequent occurrence to find a minute aperture between the two auricles through which a probe or bristle can be passed.

In those rare cases where the foramen ovale does not obliterate after birth, certain well-marked clinical symptoms are produced, giving rise to one of the forms of *congenital cyanosis.*

The foramen ovale of the fœtal heart produces the fossa ovalis of the adult heart.

The Ductus Arteriosus.—With the establishment of respiration, and the consequent sudden increase in the pulmonary circulation, blood ceases to flow through the ductus arteriosus, and its obliteration proceeds so rapidly that it is rarely found open after the eighth or tenth day of extra-uterine life, and is usually completely impervious at the end of the third week. Its obliteration produces the *ligamentum arteriosum* of the adult.

The Umbilical Arteries.—The ligation of the cord necessarily stops the circulation of blood through the umbilical arteries, though they still remain filled with arterial blood for a short time longer. Their obliteration proceeds very rapidly, however; so rapidly, in fact, that at the end of the fourth day of extra-uterine life the passage through the umbilical arteries is usually completely occluded.

The abdominal portions of the fœtal umbilical arteries remain in the adult as the two fibrous cords which are termed the *obliterated hypogastric arteries.* Their proximal ends usually remain patent and form part of the *superior vesical arteries.* All these vessels are fully described elsewhere.

Summary of the Fœtal and Adult Structures.—The following table indicates, in the adult, the ultimate fate of the various fœtal structures described:—

Fœtus.	Adult.
1. The umbilical vein.	1. The round ligament of the liver.
2. The ductus venosus.	2. The obliterated ductus venosus.
3. The foramen ovale.	3. The fossa ovalis.
4. The ductus arteriosus.	4. The ligamentum arteriosum.
5. The umbilical arteries.	5. The obliterated hypogastric arteries. Parts of the superior vesical arteries.

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